NURSERY & LANDSCAPE PLANT PRODUCTION AND IPM

Publication 383

Ministry of Agriculture,
Food and Rural Affairs

Ontario

Discard old editions of this publication. Each year the appropriate sub-committee of the Ontario Pest Management Research and Services Committee reviews the pesticides listed in this publication. To the best knowledge of the committee, at the time of printing, the pesticide products listed in this publication were:

- federally registered
- classified by the Ministry of the Environment (MOE)

The information in this publication is general information only. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) does not offer any warranty or guarantee, nor does it assume any liability for any crop loss, animal loss, health, safety or environmental hazard caused by the use of a pesticide mentioned in this publication.

This publication lists a number of brand names of pesticides. It is neither an endorsement of the product nor a suggestion that similar products are ineffective.

The Pesticide Label

Consult each product label before you use a pesticide. The label provides specific information on how to use the product safely, hazards, restrictions on use, compatibility with other products, the effect of environmental conditions, etc.

The pesticide product label is a legal document. It is against the law to use the product in any other way.

Federal Registration of Pesticide Products

The Pest Management Regulatory Agency (PMRA) of Health Canada registers pesticide products for use in Canada based on following an evaluation of scientific data to ensure that the product has merit and value; and the human health and environmental risks associated with its proposed use are acceptable.

1. **Full Registration**
   Pesticide registrations are normally granted for a period of five years, subject to renewal.

2. **Conditional Registration**
   Conditional registration may be granted for a specified, limited time period, where the registrant agrees to produce additional scientific or technical information, or the pesticide is used for emergency control of a serious pest outbreak.

Maximum Residue Limits

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For more information on the federal registration status check the PMRA website at *www.pmra-arla.gc.ca* or call 1-800-267-6315.

Regulation of Pesticides in Ontario

The MOE is responsible for regulating pesticide sale, use, transportation, storage and disposal in Ontario. Ontario regulates pesticides by placing appropriate education, licensing and/or permit requirements on their use, under the *Pesticides Act* and Regulation 63/09.

All Pesticides must be used in accordance with requirements under the *Pesticides Act* and Regulation 63/09, which are available on the e-laws website at *www.e-laws.gov.on.ca* or call ServiceOntario Publications Toll-Free number: 1-800-668-9938 or 416-326-5300.

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Growers and their Assistants

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Commercial Applicators and their Assistants

For more information about exterminator certification and licensing and technician training check the Ontario Pesticide Training & Certification website at *www.ontariopesticide.com/OPTC/default.htm* or call 1-888-620-9999 or 519-674-1575.

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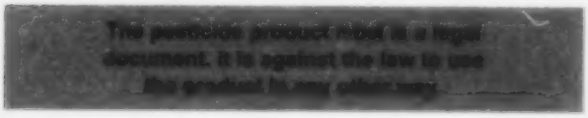

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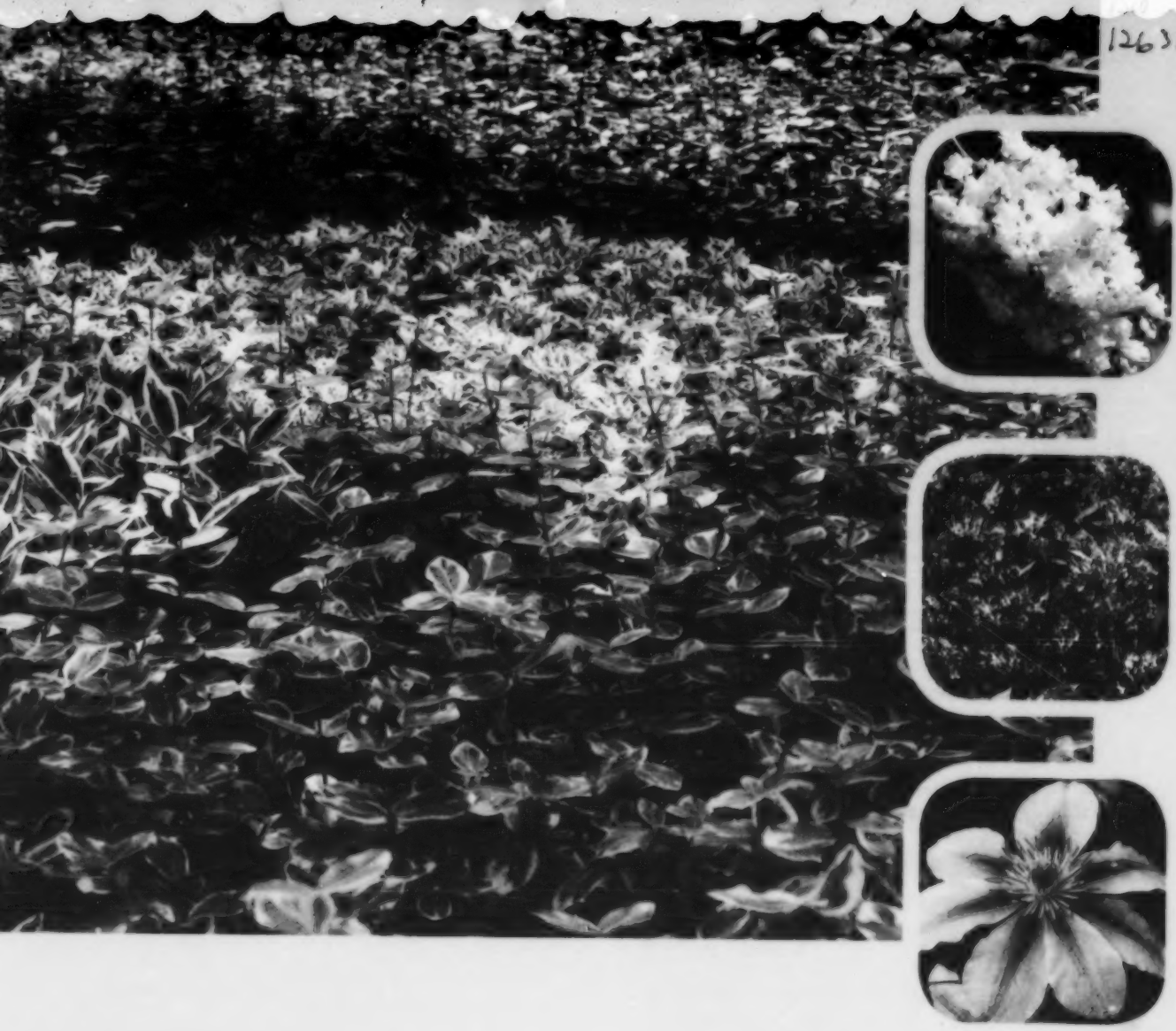

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Need technical or business information?
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ag.info.omafra@ontario.ca

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Contents

1. Using Pesticides in Ontario

Federal Registration of Pesticides 11

Regulation of Pesticides in Ontario 11

Classification of Pesticides 11

Certification and Licensing 12

Growers and Their Assistants 12
Commercial Applicators (Exterminators) and Their Assisting Technicians 12
Exception for Tree Care Specialists 12

Pesticide Application Information 12

Re-Entry Intervals 12
Days to Harvest for Food Crops (Preharvest Intervals, Pregrazing and Feeding Intervals) 12
Buffer Zones 12

Protect the Environment 12

Protect Water Sources 12
Prevent Bee Poisoning 14
Manage Drift 14

Pesticide Disposal 14

Empty Pesticide Containers 15
Surplus Spray Mix 15
Surplus Pesticides in Storage 15
Storing Pesticides 15

Pesticide Spills 16

2. Safe Use of Pesticides

Human Health 17

Risks of Pesticide Use 17
Cholinesterase Blood Tests 17

Read and Follow Pesticide Label Informaton 18

Know the Hazard Symbols and Words 18

First Aid 19

General Precautions When Using Pesticides 20

Protection When Using Pesticides 20

Protective Clothing and Equipment 20

When Working in Enclosed Areas 21

Canister Respirators 21
Self-Contained Breathing Apparatus 21
Other Protective Clothing 22
Working Conditions 22
Safety Equipment Suppliers 22

Care of Protective Clothing and Equipmont 23

Respirators 23
Rubber, Vinyl or Plastic Boots and Gloves 23
How to Wash Clothes Used for Spraying 24
Personal Hygiene 24

3. Water Quality, Media and Soil Management

Field Nursery Production 25

Field Soil Testing 25
The OMAFRA-Accredited Soil Testing Program 25
Soil Tests from Unaccredited Laboratories 26
When to Sample Field Soil 26
How to Sample Field Soil 26
Field Soil Management Practices 27
Field Soil Micronutrient Testing 27
How to Sample Field Soil Micronutrients 27
Foliar Analysis (Plant Tissue Testing) 27
When to Sample Plant Tissues 27
How to Sample Plant Tissues 27
Understanding Soil pH 28
Soil pH and Nutrient Availability 28
Buffer pH Testing 29
Limestone Type 29
Limestone Quality 29

Agricultural Index 29
Raising Soil pH 29
Tillage Depth 30
Lowering Soil pH 30
Soluble Salts in Soil 30
Fertilizer Use 31
Fertilizing Field Nursery Stock 31
Fertilizing Seed Beds and Transplant Liner Beds 31
Fertilizing Established Field Stock 31
Fertilizing Landscape Plantings 34
Fertilizer Application Rates 35
Organic Amendments to Soil 35
Organic Matter Content of Soil 35
Cover Crops 35
Grasses 37
Ryegrass (Annual, Italian or Perennial) 37
Spring Cereals (Oats, Barley, Spring Wheat, Etc.) 37
Sorghum Sudan and Forage Pearl Millet 38
Winter Rye 38
Winter Wheat 38
Legumes 39
Hairy Vetch 39
Red Clover 39
Sweet Clover 39
Non-Legume Broadleaves 40
Buckwheat 40
Oilseed Radish and Mustard 40
Tillage Systems After Cover Crops 40
Applying Manure 41
Sampling Manure 41
Timing of Manure Applications 41

Container Production 42

Using Containers 42
Potting Media 43
Using Soilless Media 43
Determining Media Porosity 43
Adjusting Potting Mix pH 44
Fertilizing Container Stock 45
How to Sample and Test Container Media 45
Using Water-Soluble Fertilizers 46
Using Controlled-Release Fertilizers 46
Measuring Nutrient Levels in Container-Grown Crops 48

Irrigation Water 48

Water Quantity 48
Water Quality 49
Water Testing 50

4. Insect and Disease Management

Integrated Pest Management 51

Monitoring 51
Crop Scouts 51
Growing Degree Days (GDD) and Phenology Models 52
Monitoring Tools 53
Monitoring Data Records 53
Indicator Plants 53
Cultural Control 54
Physical or Mechanical Control 54
Biological Control 54
Chemical Control 54

Best Management Practices 55

Insects and Mites Affecting Trees and Shrubs 56

Defoliators 56
Caterpillars 56
Leaf-Eating Beetles 56
Leafminers and Casebearers 56
Sawflies 56
Sucking Insects 57
Aphids 57
Leafhoppers 57
Mites 57
Thrips 58
Plant Bugs 58
Scale Insects 58
Armoured Scales 58
Soft Scales 58
Mealybugs 58
Borers 58
Gall Makers 58
Soil Pests 59
Japanese Beetles 59
Managing Japanese Beetles in Nurseries 59
Other White Grubs 60
Root Weevils 60
Nematodes 60
Soybean Cyst Nematode 61

Phenology and Growing Degree Day Tables for Monitoring 62

Diseases Affecting Trees and Shrubs 82

Foliar Diseases 82
Botrytis (Grey Mould) 82
Downy Mildew 82
Powdery Mildew 82
Leaf Spot and Anthracnose 83
Needlecast 83
Apple Scab 83
Pyracantha Scab 83
Crown and Root Rots 84
Cankers 84
Rust 84
Bacterial Blights 85
Crown Gall 85
Vascular Wilts 85
Virus Diseases 87
Ash Yellows 87
Elm Yellows 87
Rose Mosaic 87
Abiotic Diseases 87
Understanding Dieback 87
Fall Needle Drop of Conifers 88
Needle Browning on Conifers 88
Salt Damage 88
Salt Damage Symptoms on Conifers 88
Salt Damage Symptoms on Deciduous Plants 88
Scorch 89

Using Pesticides 89

Classifications of Pesticides for Sale and Use in Ontario 89
Toxicity Information 89

Chemical Families 89

Pesticide Application Restrictions 94

A Compendium of Pests and Diseases with Recommended Management Practices 94

ABIES — fir 94
ACER — maple 96
AESCULUS — horsechestnut 99
AMELANCHIER — serviceberry 99
BETULA — birch 100
BUXUS — boxwood 101
CARAGANA — pea shrub 101
CARYA — hickory 102
CHAENOMELES — quince 102
CLEMATIS — clematis 102
CORNUS — dogwood 103
CORYLUS — corkscrew hazel, filbert 103
COTONEASTER — cotoneaster 104
CRATAEGUS — hawthorn 104
EUONYMUS — euonymus 106
FAGUS — beech 107
FORSYTHIA — forsythia 108
FRAXINUS — ash 108
GLEDITSIA — honeylocust 110
HEDERA — ivy 111
HEMEROCALLIS — daylily 111
HERBACEOUS PERENNIALS 112
HYDRANGEA — hydrangea 113
JUGLANS — butternut, walnut 114
JUNIPERUS — juniper 114
LARIX — larch 115
LIGUSTRUM — privet 116
LIRIODENDRON — tuliptree 117
LONICERA — honeysuckle 117
MAGNOLIA — magnolia 117
MALUS — apple 118
PACHYSANDRA — pachysandra 121
PHLOX — phlox 122
PICEA — spruce 122
PINUS — pine 125
PLATANUS — London plane, sycamore 130
POPULUS — poplar 131
POTENTILLA — potentilla 132
PRUNUS — black cherry, chokecherry, flowering cherry, pin cherry, peach, plum 132
PSEUDOTSUGA — Douglas fir 135
PYRACANTHA — firethorn 135
PYRUS — pear 136
QUERCUS — oak 137
RHODODENDRON — rhododendron, azalea 140
RIBES — currant 141
ROBINIA — locust 141
ROSA — rose 142
SALIX — willow 144
SORBUS — mountain ash 146
SYRINGA — lilac 147
TAXUS — yew 149
THUJA — eastern white cedar, arborvitae 150

TILIA — linden, basswood ... 152
TSUGA — hemlock ... 154
ULMUS — elm ... 155
VIBURNUM — virburnum ... 158

5. Rodents and Deer

Vole Control ... 159
Vole Control Options ... 159
Precautions for Handling Poison Baits ... 159
Rabbit Control ... 160
Rabbit Control Options ... 160
Deer Control ... 161
Deer Control Options ... 161

6. Weed Management

Weed Control Principles ... 163
Reducing Weeds Before Planting ... 163
Use Cover Crops for Weed Suppression ... 163
Controlling Perennial Weeds ... 163
Crop Rotation ... 163
Stale Seedbeds ... 164
Preparing Container Beds ... 164
Managing Weed Sources ... 164
Mechanical Weed Control ... 164
Rotary Hoes ... 164
Inter-Row Cultivation ... 165
Mowing ... 165
Managing Herbicide Resistance ... 165
Delaying Herbicide Resistance ... 165
Chemical Weed Control ... 166
Herbicide Licensing Requirements ... 166
Applying Chemical Herbicides ... 166
Herbicide Drift ... 167
When to Use Herbicides ... 167
Application Technology ... 167
New Technologies ... 167
Sprayers for Small Areas ... 167
Field Sprayers ... 167
Air Blast or Mist Sprayers ... 168
Wiper Applicators for Selective Weed Control ... 168
Equipment Use and Care ... 168
Spraying Speeds ... 168
Using Water Correctly ... 168
Agitation ... 168
Preparing a Wettable Powder and Oil or Emulsifiable Concentrate Mix ... 168
Pumps ... 168
Nozzles ... 169
Flat-Fan Nozzle Tips ... 169
Flooding-Fan Nozzle Tips ... 169
Broadcast Nozzle Tips ... 169
Full and Hollow Cone Nozzle Tips ... 170
Nozzle Screens ... 170
Cleaning the Sprayer ... 170
Environmental Issues When Cleaning ... 170
Sprayer Calibration ... 170
Determining Application Rates in L/ha ... 170
Method 1 ... 170
Method 2 ... 171
Determining the Number of Hectares per Tankful ... 172
Calibrating Hand-Held and Backpack Sprayers ... 172
Method 1 ... 172
Method 2 ... 172
Determining the Herbicide Quantity Required ... 172
Materials, Mixing and Mixtures ... 173
Dry Formulations ... 173
Liquid Formulations ... 173
Mixing Herbicide Formulations ... 173
Application Indicators ... 173

A Compendium of Herbicides with Their Recommended Uses in Ontario — 2009 ... 173

Notes on Herbicides ... 174

PREPLANTING TREATMENTS ... 175

Soil Fumigants ... 175

◆ *dazomet*
BASAMID
dithiocarbamate ... 175

◆ *metam sodium*
VAPAM
thiocarbamate ... 176

◆ *methyl bromide/chloropicrin*
TERR-O-GAS 67
organohalogen ... 176

PREEMERGENCE TREATMENTS ... 177

◆ *chlorthal dimethyl*
DACTHAL W-75
phthalate ... 177

◆ *dichlobenil*
CASORON G-4
benzonitrile ... 178

◆ *flumioxazin*
BROADSTAR G/SUREGUARD WDG
N-phenylphthalimide derivative ... 179

◆ *isoxaben*
GALLERY 75DF
benzamide ... 181

◆ *napropamide*
DEVRINOL 2G/DEVRINOL 10G/DEVRINOL 50 DF
amide ... 181

◆ *oxadiazon*
RONSTAR 2G
oxadiazole ... 182

◆ *propyzamide*
KERB 50 WSP
amide ... 183

◆ *simazine*
PRINCEP NINE-T/SIMADEX
S-triazine ... 183

◆ *s-metolachlor*
DUAL II MAGNUM
acetanilide ... 184

◆ *trifluralin*
BONANZA 400 EC/RIVAL EC/TREFLAN EC
dinitroaniline ... 185

POSTEMERGENCE TREATMENTS ... 186

◆ *amitrole*
AMITROL 240
triazole ... 186

◆ *fluazifop-p-butyl*
VENTURE L
aryloxyphenoxypropionate ... 187

◆ *glyphosate*
various products
amino acid ... 188

◆ *paraquat*
GRAMOXONE
bipyridylium ... 189

Crop Tolerance and Efficacy of Herbicides Registered on Nursery Crops ... 189

7. Appendices

Appendix A. Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Nursery Crop Advisory Staff ... 195

Appendix B. Ontario Ministry of the Environment Regional Contact Information ... 195

Appendix C. Other Contacts ... 196

Appendix D. Diagnostic Service ... 198

Appendix E. The Metric System ... 201

Appendix F. Pest Monitoring Record Sheet ... 204

Appendix G. Colour Plates ... 205

(see page 9 for a detailed list of plates)

Tables

2. Safe Use of Pesticides

TABLE 2–1. Label Hazard Symbols and Words 18

TABLE 2–2. Ontario Suppliers of Protective Clothing and Equipment 22

3. Water Quality, Media and Soil Management

TABLE 3–1. OMAFRA-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories 25

TABLE 3–2. Average Foliar Nutrient Content of Healthy Nursery Stock 28

TABLE 3–3. Lime Requirements to Correct Soil Acidity Using Buffer pH 30

TABLE 3–4. Soil Acidification to pH 5.0 Using Sulphur 30

TABLE 3–5. Soil Electrical Conductivity (EC) Readings 31

TABLE 3–6. Phosphorus Requirements for New and Established Field Nursery Stock 32

TABLE 3–7. Potassium Requirements for New and Established Field Nursery Stock 32

TABLE 3–8. Nitrogen Sources 33

TABLE 3–9. Phosphorus Sources 33

TABLE 3–10. Potassium Sources 33

TABLE 3–11. Nitrogen Equivalency Table 34

TABLE 3–12. Optimal Organic Matter Content in Agricultural Soils 35

TABLE 3–13. Characteristics of Cover Crops Grown in Ontario 36

TABLE 3–14. Manure Application Rate and Approximate Nutrients Supplied 42

TABLE 3–15. Media Nutrient Levels for Most Container Crops 47

TABLE 3–16. Acceptable Ranges for Chemical Properties of Irrigation Water 50

4. Insect and Disease Management

TABLE 4–1. Host Symptoms and Possible Causes of Insect Injury 61

TABLE 4–2. Symptoms and Possible Causes of Insect Injury (by Visible Insect Matter) 62

TABLE 4–3. Common Phenology Plant Indicators for Ontario 63

TABLE 4–4. Monitoring for Late March to Early April (1–25 GDD Base 10˚C) 64

TABLE 4–5. Monitoring for Mid-April to Late April (25–55 GDD Base 10˚C) 65

TABLE 4–6. Monitoring for Late April to Mid-May (55–100 GDD Base 10˚C) 66

TABLE 4–7. Monitoring for Mid-May to Late May (100–150 GDD Base 10˚C) 68

TABLE 4–8. Monitoring for Late May to Early June (150–200 GDD Base 10˚C) 69

TABLE 4–9. Monitoring for Early June to Mid-June (200–250 GDD Base 10˚C) 71

TABLE 4–10. Monitoring for Mid-June (250–300 GDD Base 10˚C) 73

TABLE 4–11. Monitoring for Mid-June to Late June (300–400 GDD Base 10˚C) 75

TABLE 4–12. Monitoring for Late June to Early July (400–500 GDD Base 10˚C) 76

TABLE 4–13. Monitoring for Early July to Mid-July (500–700 GDD Base 10˚C) 77

TABLE 4–14. Monitoring for Mid-July to Late July (700–900 GDD Base 10˚C) 78

TABLE 4–15. Monitoring for Early August to Late August (900–1,100 GDD Base 10˚C) 79

TABLE 4–16. Monitoring for Late August to Mid-September (1,100–1,300 GDD Base 10˚C) 80

TABLE 4–17. Monitoring for Mid-September to Late October (1,300–1,700 GDD Base 10˚C) 81

TABLE 4–18. Woody Plants Resistant to Verticillium Wilt 86

TABLE 4–19. Woody Plants Susceptible to Verticillium Wilt 86

TABLE 4–20. Chemical Families 89

TABLE 4–21. Insecticides and Fungicides Used to Protect Ornamentals (by Product Name) 90

5. Rodents and Deer

TABLE 5–1. Rodenticides 160

6. Weed Management

TABLE 6–1. Herbicides Registered for Nursery Crops in Ontario (by Trade Name) 174

TABLE 6–2. Herbicides Registered for Nursery Crops in Ontario (by Common Name) 174

TABLE 6–3. Herbicides Registered for Use on Woody Plants 190

TABLE 6–4. Weed Susceptibility and Herbicides — Broadleaf Annuals 192

TABLE 6–5. Weed Susceptibility and Herbicides — Broadleaf Perennials 193

TABLE 6–6. Weed Susceptibility and Herbicides — Annual Grasses 194

Colour Plates

PLATE 1. Early instar spruce budworm 205
PLATE 2. Adult female cottony maple scale and eggs 205
PLATE 3. Late instar larvae of the forest tent caterpillar 205
PLATE 4. Adult female European fruit lecanium scale 205
PLATE 5. Maple trumpet skeletonizer 205
PLATE 6. Tar spot lesions, early August. 205
PLATE 7. Verticillium wilt staining of *Acer* 206
PLATE 8. Leaf blotch on *Aesculus*, July 206
PLATE 9. Mines on leaves caused by birch leaf miner 206
PLATE 10. Larval tunnels of bronze birch borer 206
PLATE 11. "D"-shaped exit hole caused by bronze birch borer 206
PLATE 12. Volutella canker on *Buxus* 206
PLATE 13. Late instar larvae of gypsy moth, late May 207
PLATE 14. Adult female gypsy moth and egg mass 207
PLATE 15. Hawthorn rust on *Crataegus*, August 207
PLATE 16. Quince rust on *Crataegus* fruit 207
PLATE 17. Damage by white grubs 207
PLATE 18. Septoria leaf spot on *Cornus*, July 207
PLATE 19. *Phytophthora* on *Cotoneaster* 208
PLATE 20. Euonymus scale adults 208
PLATE 21. Euonymus scale adults (close up) 208
PLATE 22. Euonymus webworm, June 208
PLATE 23. Leaf spots of *Euonymus* anthracnose. 208
PLATE 24. Crown gall on *Euonymus*. 208
PLATE 25. Larval gallery of emerald ash borer 209
PLATE 26. Fall webworm nest, August 209
PLATE 27. Bore hole of leopard moth. 209
PLATE 28. Leopard moth larva 209
PLATE 29. Honeylocust mite, plant bug and leafhopper damage 209
PLATE 30. Anthracnose on ash 209
PLATE 31. Adult juniper scale with crawlers 210
PLATE 32. Cedar-apple rust gall on juniper 210
PLATE 33. Cedar-hawthorn rust gall on juniper 210
PLATE 34. Juniper tip blight on juniper 210
PLATE 35. Overwintering nymphs of magnolia scale 210
PLATE 36. Magnolia scale with eggs and crawlers 210
PLATE 37. Large aphid colony 211
PLATE 38. Fall cankerworm larvae 211
PLATE 39. Spring cankerworm 211
PLATE 40. Eastern tent caterpillar larvae 211
PLATE 41. Leafhopper "burn" or stippling damage 211
PLATE 42. Fire blight on *Malus* 211
PLATE 43. Apple scab on *Malus* 212
PLATE 44. Cooley spruce gall on *Picea pungens* 212
PLATE 45. Cooley spruce gall adelgids on Douglas fir 212
PLATE 46. Eastern spruce gall on *Picea abies* 212
PLATE 47. Spruce spider mite feeding damage 212
PLATE 48. Spruce needle miner feeding damage 212
PLATE 49. *Cytospora* canker on *Picea* 213
PLATE 50. *Rhizosphaera* needlecast on *Picea* 213
PLATE 51. European pine shoot moth feeding damage 213
PLATE 52. *Hylobius pales* feeding injury 213
PLATE 53. Masses of pine bark adelgid 213
PLATE 54. Adult pine needle scale 213
PLATE 55. Adult female pine needle scale 214
PLATE 56. Pine pitch mass borer 214
PLATE 57. Pinkish white larva of pine pitch mass borer 214
PLATE 58. European pine sawfly larva 214
PLATE 59. Redheaded pine sawfly larvae 214
PLATE 60. Egg-laying sites of pine shoot beetle 214
PLATE 61. Pine shoot beetle larvae and feeding galleries 215
PLATE 62. Shoot feeding of adult pine shoot beetle 215
PLATE 63. Adult pine shoot beetle in the shoot tip 215
PLATE 64. White pine weevil feeding damage 215
PLATE 65. Larvae of white pine weevil 215
PLATE 66. *Diplodia* tip blight on *Pinus* 215
PLATE 67. *Lophodermium* needlecast on *Pinus*. 216
PLATE 68. White pine blister rust on *Pinus* 216
PLATE 69. Peachtree borer larval damage 216

PLATE 70. Lesser peachtree borer larval damage 216
PLATE 71. One of the many types of oak leaf gall 216
PLATE 72. Bore hole of red oak clearwing moth 216
PLATE 73. Physiological leaf scorch on *Quercus* 217
PLATE 74. Japanese beetle adults feeding injury 217
PLATE 75. Adult Japanese beetle 217
PLATE 76. Black spot lesions on foliage of *Rosa* 217
PLATE 77. Exit hole from emerged adult lilac borer 217
PLATE 78. Leaf blotches caused by lilac leafminer 217
PLATE 79. Powdery mildew on *Syringa*, August 218
PLATE 80. Adult black vine weevil feeding damage 218
PLATE 81. Larva, pupa and adult of black vine weevil 218
PLATE 82. Adults of Fletcher scale on *Thuja* 218
PLATE 83. Adults of taxus mealybug 218
PLATE 84. Foliar tip browning caused by cedar leaf miner 218
PLATE 85. Strawberry root weevil feeding damage 219
PLATE 86. Tarnished plant bug *(Lygus lineolaris)* nymph 219
PLATE 87. Adult strawberry root weevils 219
PLATE 88. Larval gallery of elm bark beetle 219
PLATE 89. Infection of xylem by Dutch elm disease 219
PLATE 90. Viburnum leaf beetle 219
PLATE 91. Feeding injury of viburnum leaf beetle larvae 220
PLATE 92. Egg masses of viburnum leaf beetle 220
PLATE 93. Adult elm flea weevils 220
PLATE 94. Larvae of pine false webworm 220

1. Using Pesticides in Ontario

Read the latest product label before using a pesticide!
Review the *Grower Pesticide Safety Course Manual*.
Keep detailed spray records.

Federal Registration of Pesticides

Before a pesticide can be sold or used in Ontario, it must be registered under the federal *Pest Control Products Act* (PCP Act) and be classified under the provincial *Pesticides Act*. The Pest Management Regulatory Agency (PMRA) of Health Canada registers pesticides for use in Canada following an evaluation of scientific data to ensure that the product has merit and value. It also ensures that the human health and environmental risks associated with its proposed use are acceptable.

The PMRA re-evaluates registered pesticides to determine whether today's health and environmental protection standards are still met when following the label directions. Outcomes of a re-evaluation can be:

- no change in the registration
- label amendments (i.e., changes to personal protective equipment requirements, re-entry intervals and buffer zones)
- modifications to existing maximum residue limits (MRLs)
- elimination or phasing-out of certain uses or formulations
- no further acceptance of the registration

The pesticide label is a legal document. It prescribes how the pesticide can be legally used. Off-label use is prohibited. It is against the law to use the pesticide in any other way or on any other crop or pest than as specified on the label. Labels for all registered pesticides are under Label Search on the PMRA website at www.pmra-arla.gc.ca. Ensure you have the most current label and are aware of any re-evaluation decisions.

Regulation of Pesticides in Ontario

The Ministry of the Environment (MOE) is responsible for regulating the sale, use, transportation, storage and disposal of pesticides in Ontario. Ontario regulates pesticides by placing appropriate education, licensing and/or permit requirements on their use, under the *Pesticides Act* and Regulation 63/09. All pesticides must be used in accordance with requirements under the *Pesticides Act* and Regulation 63/09, which are available on the e-laws website at www.e-laws.gov.on.ca or by calling Service Ontario at 1-800-668-9938 or 416-326-5300.

Ontario's cosmetic pesticides ban came into effect on April 22, 2009. The requirements of the cosmetic pesticides ban are detailed in Regulation 63/09 made under the *Pesticides Act*. Regulation 63/09 replaces Regulation 914. For more details on the regulation of pesticides in Ontario, please visit the Ministry of the Environment website, www.ontario.ca/pesticideban.

Classification of Pesticides

The Ontario Pesticides Advisory Committee (OPAC) is responsible for reviewing and recommending to the MOE the classification of pesticide products before they can be sold or used in Ontario. Pesticide products are classified on the basis of their toxicity, environmental or health hazard, persistence of the active ingredient or its metabolites, concentration, usage, federal class and registration status. This classification system provides the basis for regulating the distribution, availability and use of pesticide products in Ontario. Once approved by the MOE, classified products are posted on the MOE website at www.ene.gov.on.ca.

The Ontario pesticide classification system changed from 6 Schedules to 11 Classes (Regulation 63/09).

Certification and Licensing

Growers and Their Assistants

For information about certification for growers and training for assistants to growers, visit the Ontario Pesticide Education Program website at www.opep.ca or call 1-800-652-8573.

Commercial Applicators (Exterminators) and Their Assisting Technicians

For more information about exterminator licensing and technician training, visit the Ontario Pesticide Training & Certification website at www.ontariopesticide.com/OPTC/default.htm or call 1-888-620-9999 or 519-674-1575.

Exception for Tree Care Specialists

For information about requirements in the *Pesticides Act* and Regulation 63/09 for the exception regarding the use of pesticides to maintain the health of trees, see the Ministry of the Environment website (www.ontario.ca/pesticideban). Click on "What you need to know" and refer to the Factsheet *Tree Care Specialist.*

For more information about pesticide regulations, certification and licensing see:

- inside front cover of this publication
- PMRA website: www.pmra-arla.gc.ca
- PMRA Pest Management Information Service: 1-800-267-6315 (from within Canada) or 1-613-736-3799 (from outside Canada)
- Ontario Ministry of the Environment (MOE) website: www.ene.gov.on.ca
- Regional MOE Pesticides Specialist (See Appendix B. *Ontario Ministry of the Environment Regional Contact Information,* on page 195)
- Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) website: www.ontario.ca/omafra
- Ontario Pesticide Education Program (Ridgetown College) website: www.opep.ca

Pesticide Application Information

When you decide to use a pesticide, choose the most appropriate formulation and application method for your situation. Use only a properly calibrated sprayer. Choose less toxic alternatives when possible. Take all possible precautions to prevent the exposure of people and non-target organisms to the pesticide. Read the most current pesticide label thoroughly before application. The label provides important information, such as:

- directions for use (rates of application, crops it can be used on, target pests, crop rotation restrictions, total number of applications, droplet size/nozzle type, application equipment, timing and ideal weather conditions)
- required personal protective equipment
- health hazards and toxicity
- re-entry intervals
- buffer zones
- special warnings
- steps to be taken in case of an accident
- disposal

For more information on hazards, consult the Material Safety Data Sheet (MSDS) or contact the manufacturer.

Re-Entry Intervals

The re-entry interval, also referred to as Restricted Entry Interval (REI), is the period of time following a pesticide application during which workers must not enter the treatment area without wearing protective clothing and personal protective equipment. This allows any pesticide residue and vapours to dissipate from the treatment location (e.g., field), preventing the possibility of inadvertent pesticide exposure.

The PMRA reviews each pesticide to determine whether the label should include a specific re-entry interval. If the re-entry interval is not stated on the label, assume that the spray solution must be dry before re-entry can occur. Some pesticides have labels that carry a warning about working in treated crops. Follow the label recommendations.

Days to Harvest for Food Crops (Preharvest Intervals, Pregrazing and Feeding Intervals)

These intervals state the minimum time that must pass between the last pesticide application and the harvesting of the crop, or the grazing or cutting of the crop for livestock feed. If you harvest a crop before the preharvest interval (PHI) has passed, there may be pesticide residues in excess of the maximum residue limits (MRLs) set by PMRA.

To avoid exceeding the maximum residue limits, always follow the directions on the label.

Buffer Zones

Buffer zones are areas left untreated to protect an adjacent sensitive area, such as sensitive terrestrial and aquatic habitats, wellheads, non-target crops and areas where children play.

Leave a suitable buffer zone between the treatment area and adjacent sensitive areas. Buffer zones may vary depending on the method of application (i.e., aerial, field boom, hand-held sprayer). Some pesticide labels specify buffer zone requirements. Check the pesticide label for the type of buffer zone required.

Sensitive terrestrial habitats include hedgerows, grasslands, shelterbelts, windbreaks, forested areas, woodlots, vegetative strips, etc.

Sensitive aquatic habitats include lakes, reservoirs, streams, creeks, ditches, marshes, wetlands, ponds, commercial fish ponds, etc.

Setback Distances for Water Bodies

It is an offence under the federal *Fisheries Act* to introduce into water any material that may be harmful to fish or fish habitat. To protect these waters, applicators must determine a suitable setback distance between the area to be protected and the area where pesticide treatments are planned (if one is not specified on the pesticide label). The protected area includes the water body as well as adjacent riparian (riverbank) areas that contribute to fish food and habitat.

Protect the Environment

Protect Water Sources

According to the British Crop Protection Council (BCPC), between 40% and 70% of surface water pesticide contamination comes from mixing and filling areas.

You should load or mix pesticides on impermeable surfaces that are safely away from watercourses or environmentally sensitive areas. Drainage and run-off should be collected and disposed of safely (*Your Guide to Using Pesticides*, BCPC 2007).

Clean your spray equipment away from wells, ponds, streams and ditches. Apply the diluted rinse water (usually at a ratio of 10 to 1) to the treatment area (crop) but do not exceed the pesticide rate recommended on the label.

Do not make a direct connection between any water supply (e.g. public supply, wells, watercourse or pond) and a spray tank. Use an anti-backflow device or intermediate system to prevent back-siphoning that could contaminate the water supply.

Immediately contain and clean up any spills to prevent contamination to water sources.

Check the pesticide label for specific instructions on water source protection.

For more information on protecting water sources, see:

- OMAFRA Factsheet *Pesticide Contamination of Farm Water Supplies: Recommendations on Avoidance, Cleanup and Responsibilities,* Order No. 00-099
- OMAFRA Factsheet *Groundwater – An Important Rural Resource: Protecting the Quality of Groundwater Supplies,* Order No. 06-115
- OMAFRA/Agriculture and Agri-Food Canada booklet *Best Management Practices — Pesticide Storage, Handling and Application,* Order No. BMP13

Prevent Bee Poisoning

It is important to protect bees when spraying insecticides. Honeybees, as well as other bees and insects, are important pollinators of crops. Many crops also offer bees sources of nectar for honey production.

Read each pesticide label for specific precautions regarding bees. Choose less toxic alternatives when possible. Most organophosphate and carbamate insecticides are highly toxic to bees.

Advise local beekeepers before you apply a pesticide, so that they may take additional precautions to protect their bees. Contact the Provincial Apiarist at 1-888-466-2372, ext. 63595, for a list of the beekeepers in your area. Follow guidelines regarding spray timing to prevent unnecessary poisonings. For more information on preventing bee poisoning, see the "apiculture" section of the OMAFRA website at www.ontario.ca/crops.

Manage Drift

- Do not spray when wind speeds are high or gusty. These conditions will favour spray drift. Check pesticide labels for allowable wind speeds for spraying applications. Some labels may not provide this specific information. Constantly monitor wind conditions during spraying using a good-quality wind meter. Record the wind speed and direction. As wind conditions change, you may need to make adjustments to further reduce the drift potential, such as adjusting water volume upwards, minimizing nozzle-to-target distance, changing nozzle technology or changing fields because of surrounding influences, or stop spraying until conditions improve.
- Do not spray during periods of dead calm. Periods of dead calm usually occur in early morning or late evening, at which time the temperature is usually cooler and the relative humidity is typically higher. The combination of these factors can result in drift-sized droplets staying in the field. When the wind picks up, these spray droplets can move away from the target area, possibly causing injury to adjacent non-target areas.
- Use the recommended sprayer output (water volume).
- Use a nozzle that will produce the appropriate droplet size if specified on the pesticide label.
- Use the most appropriate nozzle for the type of application. Where practical, use air induction/venturi nozzles, which significantly reduce drift compared to conventional nozzles.
- Check the height of the boom to the target and minimize the distance as much as possible while still maintaining spray uniformity.
- Follow buffer zone requirements for the protection of adjacent sensitive areas as outlined on the pesticide label.
- Use spray plume protection where practical or available (hoods, shrouds, screens and air curtains).
- Use drift-reducing adjuvants in the spray tank as directed on the label.
- Use wick weeders instead of spraying when possible.
- Use non-volatile pesticide formulations or products.

For more information about spray drift, see:

- OMAFRA/Agriculture and Agri-Food Canada booklet *Best Management Practices – Pesticide Storage, Handling and Application*, Order No. BMP13
- Ontario Pesticide Education Program (University of Guelph Ridgetown Campus) videos *How to Manage Spray Drift* and *Spray Drift Reduction Through Air Induction*, available at www.opep.ca/Educational/EducationalMaterials.htm

Pesticide Disposal

Empty Pesticide Containers

Never reuse empty containers. Puncture the cleaned empty containers to make them unusable.

The Ontario Empty Pesticide Container Recycling Program is available to growers and commercial applicators. Through this program, you can return cleaned and triple-rinsed plastic/metal pesticide containers (up to 23 L for plastic and 20 L for metal) to pesticide container depots located throughout the province. Remove the paper booklet from the pesticide container before recycling. To locate the closest pesticide container recycling depot, call the Ontario Pesticide Education Program at 1-800-652-8573, contact your local dealer or municipality or visit the CropLife Canada website at www.croplife.ca.

Surplus Spray Mix

The best way to dispose of any excess spray mix is to find other fields that require an application of this pesticide. Before spraying, check the label to make sure the pesticide is registered for use on that crop.

If you cannot find another field to spray, dilute the remaining spray mix by adding 10 parts of water for each 1 part of spray mix. The diluted solution can be safely applied to the original treated area as long as you do not exceed the pesticide rate recommended on the label. Be sure to check the label for any restrictions about crop rotation, days to harvest or surplus spray mix disposal.

Never re-spray the treated field with undiluted spray mix. Spraying an area twice will double the recommended pesticide rate. This may cause illegal pesticide residues in the harvested crop or harmful residues in the soil that can cause crop damage.

Surplus Pesticides in Storage

Be sure to safely dispose of pesticides that you do not need or cannot use. Options for proper disposal include:

- Contact the supplier. It is sometimes possible to return unused pesticide if it is still in its original, unopened container.
- Hire a waste hauler who is licensed under Part V of the *Environmental Protection Act* to carry hazardous wastes. Look in the Yellow Pages of your telephone directory under Liquid Waste Removal.
- Check your local paper or visit the CropLife Canada website (www.croplife.ca) for upcoming Obsolete Pesticide Collection Days.
- Contact your municipality to see if any waste collection days are scheduled and verify whether quantities of agricultural pesticides will be accepted.

Storing Pesticides

Ontario's *Pesticides Act* and Regulation 63/09 provide details on storage requirements for storage facilities. The storage requirements that must be followed are dependent on which classes of pesticides you store.

For more information about storing pesticides, see:

- OMAFRA Factsheet *Farm Pesticide Storage Facility*, Order No. 07-059
- OMAFRA/Agriculture and Agri-Food Canada booklet *Best Management Practices — Pesticide Storage, Handling and Application*, Order No. BMP13
- Ontario Pesticide Education Program (University of Guelph Ridgetown Campus) *Grower Pesticide Safety Course Manual*, available at www.opep.ca/Educational/EducationalMaterials.htm

Pesticide Spills

If a pesticide spill causes, or is likely to cause, an adverse effect that is greater than that which would result from the proper use of the pesticide, you must notify the Ministry of the Environment Spills Action Centre at 1-800-268-6060 (24 hours a day, 7 days a week) and your municipality.

A spill is defined as a discharge of pollutant that is abnormal in quality or quantity, from or out of a structure, vehicle or other container into the environment. An incident such as an overturned pesticide sprayer that results in the loss of the spray solution to the environment is an example of a spill. A pesticide container that ruptures and leaks its contents is another example of a spill. The discharge or spraying of a pesticide in an unapproved area, commonly referred to as an overspray, is also considered a spill.

Before you begin to clean up a spill of any nature, remember to protect yourself against pesticide exposure. Wear the proper protective clothing and personal protective equipment. If the spill occurs inside an enclosed area (e.g., a pesticide storage area or a vehicle during transport), ventilate the area first. Once you have protected and/or removed yourself and other persons or animals from the spill site, take additional measures to stop the spill at the source and prevent it from spreading and/or contaminating watercourses. Specific precautions, emergency contact information and first aid procedures may be found on the label.

For minor spills, it may be possible to remediate the problem:

- **For a liquid spill** — Cover the spill with a thick layer of absorbent material such as kitty litter, vermiculite or dry soil. Sweep or shovel the material into a waste drum and dispose of the contents as you would a hazardous waste.
- **For a dust, granular or powder spill** — Sweep or shovel the material into a waste drum and dispose of the contents as you would a hazardous waste.

For major spills, it is essential to stop the spill from spreading. The cleanup guidelines above may not be appropriate for all spill situations. Once you have contained the spill, follow directions from the manufacturer and regulatory authorities on cleaning the contaminated area.

For information on preventing spills, see:

- OMAFRA Factsheet *Ways to Avoid Pesticide Spills,* Order No. 96-025
- OMAFRA/Agriculture and Agri-Food Canada booklet *Best Management Practices – Pesticide Storage, Handling and Application,* Order No. BMP13
- Ontario Pesticide Education Program (University of Guelph Ridgetown Campus) Grower Pesticide Safety Course Manual, available at www.opep.ca/Educational/EducationalMaterials.htm

For pesticide poisonings and pesticide injuries call:

Poison Information Centre
1-800-268-9017
(TTY) 1-877-750-2233

For more information, see inside back cover on *Emergency and First Aid Procedures for Pesticide Poisoning.*

2. Safe Use of Pesticides

Human Health

Risks of Pesticide Use

Each time a pesticide is handled, there is some risk. The amount of risk depends on two things — the toxicity of that pesticide and the degree of exposure to it.

Risk = Toxicity × Exposure

Toxicity is a measure of how harmful or poisonous the pesticide is. There are two types of toxicity:

- **Acute toxicity** — the toxic response that results from a single exposure to the pesticide. The symbols and words on the front panel of a pesticide label give information about the acute toxicity (See Table 2–1, *Label Hazard Symbols and Words*, on page 18).

Lethal dose 50% (LD_{50}) is a measure of acute toxicity. It is the dose (in mg of product per kg of body weight) that will kill 50% of test animals (usually female rats) within a stated period of time (24 hours to 7 days). This is commonly measured as the acute oral LD_{50}, which refers to the chemical ingested through the mouth or nose. Dermal LD_{50} figures, or skin penetration, are also available. The oral LD_{50} of a pesticide is listed in Table 4-21, *Insecticides and Fungicides used to Protect Ornamentals*, on page 90.

The lower the LD_{50} figure, the more toxic the product is to humans.

Examples of products with a high acute toxicity include:

Common (Active) Name	Trade Name
chlorpyrifos	Dursban, Pyrate
dichlorvos	DDVP
endosulfan	Endosulfan, Thiodan, Thionex
methomyl	Lannate
pirimicarb	Pirliss

- **Chronic toxicity** — the toxic response that results from repeated exposure to small doses of a pesticide over a longer period of time. These toxic effects may not appear for months or years after exposure to the pesticide. The symbols on the label do not give information about the chronic toxicity of the product. Use protective clothing and equipment to help reduce exposure and risk of chronic effects.

Exposure is a measure of the contact with the pesticide. Workers can be exposed to the pesticide in three ways:

- **Dermal exposure** occurs through the skin or eyes. The amount and rate of pesticide that may be absorbed depends on several things, including:
  - Skin condition at time of exposure: If the skin is moist, or if a rash, broken skin or scratches are present, pesticides will be absorbed more easily.
  - Part of the body that is exposed: Eyes, genital area, scalp and ear canals absorb pesticides at a higher rate than hands or arms. Eyes absorb pesticides at a rate of 100%.
- **Respiratory exposure (inhalation)** occurs when small spray particles, dust, gases or vapours are inhaled.
- **Oral exposure** occurs when a pesticide enters the mouth or is swallowed.

Cholinesterase Blood Tests

Organophosphorus and carbamate pesticides can affect the human nervous system (see Table 4-21, *Insecticides and Fungicides Used to Protect Ornamentals*, on page 90 for a list of organophosphorus and carbamate pesticides). These pesticides can reduce the levels of the enzyme acetyl cholinesterase in the serum and red blood cells. The body uses this enzyme to transmit messages through the nervous system. If cholinesterase levels fall, individuals experience symptoms such as trembling, twitching, blurred vision, and breathing and heart difficulties.

People who use any organophosphorus and carbamate pesticides on a routine basis should have regular cholinesterase blood tests. A family doctor can arrange these tests, which are covered by the Ontario Health Insurance Plan (OHIP). Workers should have their first test before beginning to handle these pesticides to show their normal (baseline) cholinesterase level.

During the spray season, workers who spray organophosphorus or carbamate insecticides regularly for several weeks should have a cholinesterase blood test every 7 to 10 days. If the worker's cholinesterase level drops to less than half of the baseline level, the worker is showing signs of pesticide poisoning and must prevent exposure to these pesticides until cholinesterase levels return to normal.

Examples of products that contain organophosphorus or carbamate insecticides include:

Common (Active) Name	Trade Name
acephate	Orthene
bendiocarb	Trumpet
dichlorvos	DDVP
malathion	Malathion
naled	Dibrom
pirimicarb	Pirliss

Read and Follow Pesticide Label Information

Know the Hazard Symbols and Words

Four important symbols and words show the potential hazards of pesticides.

TABLE 2-1. Label Hazard Symbols and Words

Hazard Symbol	Signal Word
	Poison
	Corrosive
	Flammable
	Explosive

The hazard symbol always appears inside one of the shapes shown below. The shape and its signal word together indicate the degree of hazard of the pesticide. The greater the number of sides of the shape, the more hazardous the product.

	Warning Symbol	Signal Word
Triangular shape means low hazard (3 sides)		Caution
Diamond shape means moderate hazard (4 sides)		Warning
Octagonal shape means high hazard (8 sides)		Danger

Learn these symbols and words — they could save your life!

Check the label for special warnings about eye hazards and skin hazards. The front panel of the

pesticide label may also contain warnings that indicate whether the product is corrosive to eyes or is a skin or eye irritant.

First Aid

If an accident occurs:

1. Rescuers should always protect themselves from injury. Protective clothing and equipment should always be worn before entering a contaminated area or handling a contaminated victim.

Symptoms of Pesticide Poisoning

Mild Symptoms

Headache, fatigue (tired feeling), loss of appetite, dizziness, weakness, nervousness, nausea, perspiration, diarrhoea, loss of weight, thirst, moodiness, irritation of the skin, eyes, nose or throat.

Moderate Symptoms

Nausea, trembling, loss of muscular co-ordination, excessive saliva, blurred vision, constricted throat or chest, laboured breathing, flushed or yellow skin, abdominal cramps, vomiting, diarrhoea, mental confusion, perspiration, rapid pulse, cough.

Severe Symptoms

Vomiting, loss of reflexes, not able to breathe or increased breathing rate, muscle twitching, tiny pupils, convulsions, unconsciousness, thirst, fever.

(Source: *Grower Pesticide Safety Course Manual,* University of Guelph Ridgetown Campus. Available online at www.opep.ca.)

If symptoms occur during or shortly after handling a pesticide, go to a hospital. Take the pesticide label, Material Data Safety Sheet (MSDS) or pesticide container. Do not transport the container in the passenger compartment. See the Emergency Procedures for Pesticide Poisoning on the inside back cover.

2. Check to see if the victim is breathing.

If the victim is not breathing:

- Straighten the victim's airway and check for breaths.
- If the victim does not begin to breathe, perform artificial respiration until the victim begins to breathe independently.
- Avoid becoming contaminated, especially if the victim has pesticide or vomit around the face or mouth. Use a face shield airway with a one-way valve. Do not breathe the exhaled air from the victim.
- If the victim's pulse disappears, perform CPR if qualified to do so.

If the victim is breathing, but unconscious:

- Place the victim in the recovery position (on the side with the head turned slightly to one side). If the victim vomits, try to keep the airway clear.

3. Stop the exposure to the pesticide. Move the victim away from the contaminated area. Remove all contaminated clothing. Use soap and water to wash any skin exposed to the pesticide.

4. Check the four basic facts:

- What? Identify the pesticide. Look for the label, container or leftover pesticide.
- How much? How much product was the victim exposed to?

- Where? How did the pesticide enter the body? Did it enter through the mouth, skin, eyes or lungs?
- When? How much time has passed since the victim was exposed to the pesticide, and how long was the exposure? Were the symptoms immediate or did the poisoning occur as a result of using the pesticide over a longer period of time?

Don't waste time.
If you can't answer these questions quickly, be ready to tell emergency personnel whatever you can.

5. Call an ambulance or the poison information centre.
6. Start the first aid treatment appropriate for the contaminant and route of entry. First aid instructions can be found on most pesticide labels.
7. Make sure the patient gets medical attention. First aid is not a substitute for professional medical help.

General Precautions When Using Pesticides

Always read the label:

- before buying a pesticide
- before using a pesticide
- before storing or disposing of a pesticide

Always keep records of pesticide use.

Learn about the health hazards and toxic properties of the pesticide being used. Consult the product label, Material Safety Data Sheets (MSDS) or manufacturer for this information. Check the company's website for MSDS information.

Protection When Using Pesticides

Tell someone where the work is taking place, what pesticides are being handled and how long the job is expected to take.

Post emergency numbers, including the numbers for the Poison Information Centre and Spills Action Centre, near all telephones.

Keep a list of the names and the *Pest Control Products (PCP) Act* Registration Numbers of all the pesticides handled. It's a good idea to keep a file of the pesticide label booklets for all the products used. Ensure that co-workers and family members know where to find this list or file in case of an accident.

Have plenty of clean water, soap and paper towels—and an extra set of gloves and coveralls—nearby at all times in case a pesticide contaminates clothing or skin.

Wear the correct protective clothing and equipment and be sure that all items are clean and in good repair before wearing or using them.

Never smoke, chew tobacco, eat or drink when handling pesticides. Never carry tobacco or food in clothes; never leave tobacco, food or beverages in areas where handling or storing pesticides.

Change clothes and wash hands and face before eating, drinking or smoking.

Wash hands before using the toilet, as well as after. The skin in the groin area absorbs pesticides very easily.

Protective Clothing and Equipment

Choose and wear the appropriate protective clothing and equipment. Make sure protective clothing and equipment fit properly and are clean, in good repair and in working condition. The protective clothing and equipment workers should wear depends on:

- **The pesticide being used** — read the precautions section of the label to know what is required.
- **The job being done** — for example, use more protection when handling concentrated pesticide or when mixing and loading a sprayer.
- **The type of application** — enclosed space or air-blast sprayer applications made with open tractors require more equipment.

All persons who work with pesticides need their own set of protective clothing and equipment. Consult

the product label to find out what protective clothing is required.

For all pesticides, always wear:

- A water-repellent hat, such as a hard hat or waterproof rain hat
  - Sometimes the entire head and neck must be protected: for example, if applying pesticides in a greenhouse, applying dusty formulations or using an air-blast sprayer. In these situations, wear a hood or hat that protects the ear canals. Do not wear baseball-style or other cloth hats, which absorb pesticides and are not safe.
- Long pants and a long-sleeved shirt or coveralls
  - Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. Disposable coveralls should be designated for pesticide use.
  - Water-resistant coveralls are preferred because cotton, denim and cotton/polyester pants cling to the skin if they get wet, which increases the risk of dermal exposure.
- Chemical-resistant gloves (unlined)
  - Use neoprene or nitrile gloves (PVC), unless the label states otherwise. Do not wear rubber gloves, because many pesticides can break down the rubber material. Fold up the cuffs of the gloves and wear the gloves tucked under the shirt or jacket sleeves.
- Chemical-resistant boots (unlined)
  - Wear pant legs over boots to prevent pesticide from running down inside the boots.

Read the label. It will describe what extra protective clothing and equipment to wear.

For some pesticides, workers should also wear:

- Goggles
  - Use safety goggles with indirect vents so that splashes do not enter the eye. Regular eyeglasses do not provide complete protection. Never wear contact lenses when handling pesticides.
- Face shield
- Chemical-resistant apron
- Respirator
  - A respirator is a unit that covers the mouth and nose to prevent spray droplets, small particles and vapours from entering the lungs. A dust mask is not a substitute for a pesticide respirator. Respirators and replacement cartridges should be NIOSH/MSHA approved. Use cartridges and pre-filters that protect against organic vapours. For more information about respirators, see the *Grower Pesticide Safety Course Manual*, Ridgetown College, University of Guelph.

For fumigants:

- When handling methyl bromide, do not wear gloves because they will trap gas next to the skin. Wear a full-face respirator with organic vapour canister or positive-pressure breathing apparatus. Some methyl bromide products require, by label, that self-contained breathing apparatus be worn at all times while using the product.
- When handling aluminum phosphide, use cotton gloves and wear a NIOSH/MSHA approved full-face mask respirator with an acid-gas canister. Note: always check the label to find the appropriate safety equipment requirements.

When Working in Enclosed Areas

Canister Respirators

Canister gas masks are effective for protection against certain harmful gases, vapours and particulate matter. They are generally suitable for ventilated areas where conditions don't change rapidly. They should never be used in confined spaces where oxygen deficiency or high gas concentrations may occur.

Self-Contained Breathing Apparatus

Air-purifying devices do not work in confined spaces where gas concentrations are unusually high. The lack of oxygen can prove fatal. Under these conditions, use an air supply provided by a self-contained breathing apparatus (e.g., Scott Air Pack).

Substances that produce hydrogen cyanide, methyl bromide, chloropicrin or phosphine can produce

high gas concentrations and reduce oxygen levels. A similar situation is caused by the use of smoke generators and foggers that use highly toxic pesticides and certain volatile sprays.

Other Protective Clothing

Wear other protective clothing in keeping with the requirements listed on the pesticide label.

Working Conditions

Always check and follow the label for appropriate safety equipment requirements. Use the recommendations below as a guide only.

Use canister respirators when the surrounding air contains low concentrations of toxic gases, vapours or particulate matter derived from soil-drench, granular, dust or foliar spray applications. Pesticides applied in this manner usually have moderate to low toxicity.

Use a self-contained breathing apparatus (e.g., Scott Air Pack) when applying highly toxic pesticides. Pesticides can produce high concentrations of toxic gases, vapours or particulate matter, as well as a lack of oxygen, especially in an enclosed space (e.g., when fumigating grain).

- Read the product label for recommendations and legal requirements. A list of safety supply companies can be found in Table 2–2, *Ontario Suppliers of Protective Clothing and Equipment*, below.

Safety Equipment Suppliers

Read the label for safety equipment recommendations and requirements. Protective clothing and equipment can be purchased from the suppliers listed in Table 2–2.

TABLE 2-2. Ontario Suppliers of Protective Clothing and Equipment

3-M Canada Inc.	Occupational Health and Environmental Safety Box 5757 London, ON N6A 4T1	Tel: 519-451-2500 Toll-free: 1-800-364-3577 Fax: 519-452-6720
Acklands Grainger	90 West Beaver Creek Road Richmond Hill, ON L4B 1E7	Tel: 905-731-5516 Toll-free: 1-800-668-8989
Aearo Canada	6889 Rexwood Road Mississauga, ON L4V 1R2	Tel: 905-795-0700 Toll-free: 1-800-387-4304 Fax: 905-564-5250
DuPont Personal Protection	45 Dalkeith Drive Brantford, ON N3P 1M1	Tel: 519-753-9306 Toll-free: 1-800-387-9326 Fax: 519-752-2161
Dutch Industries "Protect-Air Cab Filter"	Huron Tractor 305 Main Street North Exeter, ON N0M 1S3	Tel: 519-235-1115 Fax: 519-235-1939
HAMISCO	3392 Wonderland Road London, ON N6L 1A8	Tel: 519-652-9800 Toll-free: 1-800-668-9800 Fax: 519-652-9661
Levitt-Safety (Eastern) Limited	2872 Bristol Circle Oakville, ON L6H 5T5	Tel: 905-829-3299 Toll-free: 1-888-453-8488 Fax: 905-829-2919
Mitt & Robe Co.	751 Norfolk Street North Simcoe, ON N3Y 3R6	Tel: 519-428-4050 Toll-free: 1-877-893-6565 Fax: 519-428-5142

MSA Canada Inc.	5535 Eglinton Avenue West Unit 222 Toronto, ON M9C 5K5	Tel: 416-620-4225 Toll-free: 1-800-267-0672 Fax: 416-620-9697
Plant Products Co. Ltd.	314 Orenda Road Brampton, ON L6T 1G1	Tel: 905-793-7000 Toll-free: 1-800-387-2449 Fax: 905-793-9157
Safety Express	4190 Sladeview Crescent Units 1 and 2 Mississauga, ON L5L 5Y5	Tel: 905-608-0111 Toll-free: 1-800-465-3898 Fax: 905-608-0091
The St. George Company (Suppliers of Kasco Helmets)	20 Consolidated Drive P.O. Box 430 Paris, ON N3L 3T5	Tel: 519-442-2046 Toll-free: 1-800-461-4299 Fax: 519-442-7191

Care of Protective Clothing and Equipment

After completing the spray operation, clean all protective clothing and equipment.

Never let children, pets or livestock come in contact with contaminated clothing or equipment. Also ensure that they cannot come into contact with the puddles of water that result when cleaning equipment.

Wash gloves with soap and water and then leave them on while removing other protective clothing and equipment.

Always remove protective clothing and equipment outdoors. If a granular pesticide was used, shake the clothing outdoors in a safe place. Be sure to empty pockets and cuffs.

Dispose of clothing that has been contaminated by spills of highly toxic or concentrated pesticide. Place contaminated clothing in a plastic bag and take it to a landfill site.

Continue to wear gloves while washing protective equipment. It is best to wash equipment outdoors. If the work area does not have a cleanup area outside, designate specific buckets just for equipment cleanup. Mark them and keep them in a designated place. Wash the inside and outside of goggles, hats, boots and any water-repellent clothing in warm soapy water, then rinse them well and let them air-dry.

Respirators

Remove the cartridges and prefilters from the respirator.

Discard cartridges, canisters and filter pads at the interval set by the manufacturer or earlier if breathing becomes difficult or a pesticide taste or odour is noticed.

Record the date the cartridge is first used.

Remove cartridges and filter pads from the face piece and store them in clean, sealed plastic bags.

Wash the face piece in warm soapy water, rinse it thoroughly and dry it in a well-ventilated area. Air-drying prevents damage to the inlet and outlet valves.

Never use alcohol or other solvents for cleaning because they will damage the rubber and plastic.

Rubber, Vinyl or Plastic Boots and Gloves

To avoid contact with pesticides, wash the outside of boots and gloves with detergent and water before taking them off.

After removing boots and gloves, wash them inside and out with detergent and water, rinse them thoroughly and dry them in a well-ventilated area.

How to Wash Clothes Used for Spraying

Never mix spray clothing with household laundry. All clothing used for spraying must be stored and washed separately from other clothing. Wash spray clothing after each use. Remember to use chemical-resistant gloves to handle pesticide-contaminated clothing.

Presoak clothing before washing. Use one of three methods:

- hose off garments outdoors
- soak in separate tub or pail
- use the prewash cycle in an automatic washer

Use hot water, a heavy-duty detergent and the highest water level and the longest cycle the washing machine offers. Follow the instructions that came with the machine for washing heavily soiled clothing.

Wash clothing twice.

After washing it, hang it outside (preferably in bright sunlight) until it is completely dry. Do not use a clothes dryer.

Clean the washing machine. Run the washing machine through one complete cycle using only detergent and hot water (no clothing). After laundering, place clean clothing in a plastic bag and keep them separate from other clothing.

Personal Hygiene

Always wash hands before eating, drinking or smoking.

When finished for the day, take a bath or shower as soon as possible. The longer a pesticide remains on the skin, the greater the risk that it will be absorbed into the body.

Wash hair and scrub under fingernails. Shower with a lot of soap and water.

Always change into clean clothes.

Wear clean work clothes every day. A small spill on the previous day's clothes may seem unimportant, but wearing the same clothing again without washing it prolongs exposure and increases risk.

3. Water Quality, Media and Soil Management

When used correctly, fertilizers can help produce cost-effective, high crop yields. Always apply fertilizers at a rate consistent with soil fertility, measured by OMAFRA-accredited testing (see Table 3–1, *OMAFRA-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories*, on page 25). Low-fertility soils may need nitrogen, phosphorus, potassium and micronutrients at levels at least equal to crop removal. However, high-fertility or heavily manured soils may not benefit from added fertilizer due to increased costs and possibly reduced yields.

Field Nursery Production

Field Soil Testing

The OMAFRA-Accredited Soil Testing Program

Be sure to use an accredited testing service. To be accredited, a laboratory must use OMAFRA-approved testing procedures, demonstrate acceptable analytical accuracy and precision and provide OMAFRA fertilizer recommendations based on the test results.

The OMAFRA-Accredited Soil Testing Program enables optimum fertilizer and lime application for crop production. Use this program, along with plant analysis and observation of plant nutrient–deficiency symptoms, to determine the fertilizer requirements for a specific crop on a specific field.

The program recommends the amounts of phosphate, potash and magnesium fertilizers needed, plus the type and amount of lime. The OMAFRA-recommended application rates provided in this publication should produce high economic yields when accompanied by good management practices. Research shows that higher application rates will sometimes produce higher yields, but the increase is likely to be small and not worth the additional cost.

TABLE 3–1. OMAFRA-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories

Laboratory	Media Tested	Address	Phone/Fax/Website/ E-mail	Contact
A & L Canada Laboratories East	Soil, leaf	2136 Jetstream Road London, ON N5V 3P5	Tel: 519-457-2575 Fax: 519-457-2664 www.alcanada.com aginfo@alcanada.com	Ian McLachlin Greg Patterson
Accutest Laboratories	Soil, leaf	146 Colonnade Road Unit #8 Nepean, ON K2E 7Y1	Tel: 613-727-5692 Fax: 613-727-5222 www.accutestlabs.com phaulena@accutestlabs.com	Peter Haulena Rob Walker Lorna Wilson
Agri-Food Laboratories	Soil, leaf, greenhouse media	503 Imperial Road Unit #1 Guelph, ON N1H 6T9	Tel: 519-837-1600 or 1-800-265-7175 Fax: 519-837-1242 www.agtest.com lab@agtest.com	Trish Kelly and Jack Legg
Brookside Laboratories Inc.	Soil	301 South Main Street New Knoxville, OH 45871 USA	Tel: 419-753-2248 Fax: 419-753-2949 greg@blinc.com www.blinc.com/intro.htm	Greg Meyer

TABLE 3–1. OMAFRA-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories *Continued*

Forest Laboratory	Soil	955 Oliver Road BB1005D Thunder Bay, ON P7B 5E1	Tel: 807-343-8639 Fax: 807-343-8116 soilslab@lakeheadu.ca	Claire Riddell Joel Symonds
Soil and Nutrient Lab, University of Guelph	Soil, leaf	P.O. Box 3650 95 Stone Road West Guelph, ON N1H 8J7	Tel: 519-767-6226 Fax: 519-767-6240 www.uoguelph.ca/labserv/units/soil-nutrient/	Nicole Fisher Mark Flock
Stratford Agri Analysis	Soil, leaf	1131 Erie Street Box 760 Stratford, ON N5A 6W1	Tel: 519-273-4411 or 1-800-323-9089 Fax: 519-273-4411 www.stratfordagri.ca laboratory@daconutrition.com	Keith Lemp Jim Brimner

Soil Tests from Unaccredited Laboratories

Some farmers ask OMAFRA staff to interpret results from unaccredited laboratories. If the laboratory correctly uses tests identical to those used by OMAFRA-accredited laboratories and expresses test results in the same units, the OMAFRA fertilizer requirements for phosphate and potash can then be determined.

Soil tests such as exchange capacity, aluminum and copper are not accredited by OMAFRA because these tests do not contribute to better fertilizer recommendations. For example, research shows that on Ontario soils, using exchange capacity to adjust potash recommendations can reduce the reliability of the recommendations.

The laboratories listed in Table 3–1 on page 25 are accredited to perform soil tests on Ontario soils and to analyze plant and greenhouse media samples. Please note that these labs may also offer other testing services that are not accredited by OMAFRA.

When to Sample Field Soil

Always allow enough lead time for a soil analysis. Take soil samples in the autumn from fields to be fertilized the spring. To avoid problems with bad weather in late fall, fields may also be sampled earlier in the season.

How to Sample Field Soil

It is important to sample soil correctly. To sample soil:

- Use a sampling tube or a shovel to sample soils.
- Sample each field or uniform section of a field separately.
- Take at least 20 soil cores, 15 cm deep, from any field or area up to 5 ha in size. Take proportionately more cores from fields larger than 5 ha. One sample should not represent more than 10 ha. The more cores collected, the more likely the soil sample will reliably measure the field's fertility.
- Use a zigzag pattern to distribute the sampling sites evenly across the field.
- If the soil or crops look different in different sections of the field, or if sections of the field were previously fertilized, manured or limed differently, sample those sections separately, even if these areas are too small to fertilize separately in the future.
- Do not sample recent fertilizer bands, dead furrows, areas adjacent to gravel roads, or areas where lime, manure, compost or crop residues have been piled.
- Collect the soil in a clean plastic pail. Do not use galvanized pails.
- Break up the lumps and mix the soil thoroughly (preferably with hands).

- Contact the OMAFRA-accredited lab for soil sample boxes. Place about 250 mL of the collected, well-mixed soil in a plastic bag, put the bag in a soil sample box and label the sample (e.g., date, field, depth, other information). Soils for nitrate-nitrogen analysis must be kept cool (≤ 4°C). It's a good idea to keep all soil and water samples cool until they are delivered to the lab for analysis.
- Sample each field once every 2 or 3 years.
- Be sure to enclose a field information sheet with every soil sample.

Field Soil Management Practices

Good soil management practices, including fertilization, play a major role in ensuring a profitable crop yield. In order to provide a reliable fertilizer recommendation, laboratories need information about the field, the crop to be fertilized, manure application and legume sod ploughed down. Record this information on the field information sheet that must accompany each soil sample sent for analysis. For more information, see *Best Management Practices: Managing Crop Nutrients,* Order No. BMP20E.

Field Soil Micronutrient Testing

OMAFRA offers accredited tests for manganese and zinc. Use these tests in conjunction with visible deficiency symptoms and plant analysis. OMAFRA-accredited tests are not available for boron, copper, iron or molybdenum.

- Manganese availability decreases with increasing soil pH. Do not add more lime than is needed to correct acidity.
- Control zinc deficiency by preventing soil erosion and using animal manures. If necessary, prompt use of zinc fertilizers and foliar sprays can reverse zinc deficiencies after symptoms appear.
- If a zinc soil test value exceeds 200, zinc contamination of the sample or field is possible.

How to Sample Field Soil Micronutrients

It is important to sample soil correctly. See *How to Sample Field Soil,* on page 26, for soil sampling instructions. Micronutrient deficiencies often occur in small patches. In these cases, soil and plant samples taken from the entire field may not reveal the problem. It is best to sample problem areas separately.

Use clean, plastic containers in good condition. Soils being tested for micronutrients can be easily contaminated by dirty or dusty sampling tools and containers. Do not collect or mix samples in metal containers. Galvanized (zinc-plated) sampling tools will elevate soil test results for zinc.

Foliar Analysis (Plant Tissue Testing)

Foliar analysis is the best way to diagnose micronutrient problems. It measures the nutrient content of plant tissue. OMAFRA uses foliar analysis to diagnose suspected nutrient disorders in field-grown and container-grown nursery stock. See Table 3–2, *Average Foliar Nutrient Content of Healthy Nursery Stock,* on page 28.

When to Sample Plant Tissues

Nutrient levels vary widely with plant age. It is best to take plant tissue samples in July or early August for routine analysis or whenever symptoms appear.

How to Sample Plant Tissues

It is important to sample plant tissues correctly. From deciduous trees and broadleaf evergreen shrubs, select approximately 50 fully expanded leaves midway along a shoot of the current season's growth. From conifers, select 15–20 shoots of current season growth, each approximately 10 cm long. Remove the needles and and rinse them in distilled water (discard the twigs). Deliver fresh plant materials directly to the laboratory. If they cannot be delivered immediately, air-dry the tissue samples and ship them in paper bags to avoid spoilage. Submit a sample of healthy leaves from the same area to allow comparisons.

See Table 3–1 on page 25 for a list of labs and the tests provided by each one.

Understanding Soil pH

pH measures soil acidity or alkalinity on a scale from 0 to 14. The midpoint of the scale, 7, is neutral. Values below 7 are increasingly more acid, while values above 7 are increasingly more alkaline. In general, use lime to raise pH (making the soil more alkaline) and sulphur to lower pH (making the soil more acid). Soil pH testing helps determine any necessary pH adjustments.

Soil pH and Nutrient Availability

- Many soils in Ontario have an alkaline pH. Iron (Fe) and manganese (Mn) solubility (and therefore availability) decreases with rising pH (pH > 6.0). Symptoms of iron and manganese deficiency appear as yellow leaves with green veins ("interveinal chlorosis"). Manganese deficiencies are more common than iron deficiencies.
- Most nursery stock grows well between pH 5.0 and pH 7.2.
- Plants such as red maple, pine, oak, tuliptree and euonymus may exhibit iron and/or manganese interveinal chlorosis if the pH is above 6.5. Manganese deficiency is more common than iron deficiency.
- For ericaceous plants and conifer seed beds, the pH should be below 6.5.
- Long-term use of fertilizers such as ammonium sulphate, ammonium nitrate, urea, potassium sulphate and mono-ammonium phosphate will gradually reduce soil pH. This is most likely to occur on light, sandy soils and can be corrected by liming the soil.
- Anhydrous ammonia causes a marked, though temporary, soil pH increase when first applied.
- Superphosphate and muriate of potash have little or no effect on soil pH.

Table 3–2 specifies normal foliar nutrient concentrations for nursery stock. Established landscape stock nutrient concentrations may be somewhat lower.

TABLE 3–2. Average Foliar Nutrient Content of Healthy Nursery Stock

Nutrient	N %	P %	K %	Ca %	Mg %	Mn ppm	Cu ppm	Zn ppm	B ppm	Fe ppm
Field-grown										
Conifers	1.7	0.24	1.0	1.0	0.2	88	6	31	35	87
Broadleaf evergreens	2.3	0.27	1.1	2.5	0.3	25	5	27	42	120
Deciduous trees and shrubs	2.8	0.25	1.7	2.4	0.4	62	7	25	58	133
Container-grown										
Conifers and broadleaf evergreens	2.5	0.4	1.4	2.0	0.3	52	5	24	48	127

Buffer pH Testing

Different soils with identical pH values will require different amounts of lime or sulphur to reach a desired pH level depending on clay and organic matter content. Where soil is acidic (pH > 7), an additional soil test, the buffer pH, determines the amount of lime required to increase pH appropriately. The actual lime recommendation is also determined by the target pH for the crop. The lower the buffer pH value on a soil test, the more lime that will be required to neutralize it.

Limestone Type

Both calcitic limestone and dolomitic limestone are available in Ontario. Calcitic limestone is mainly calcium carbonate, while dolomitic limestone is a mixture of calcium and magnesium carbonates. Use dolomitic limestone when the magnesium in the soil is 100 ppm or less. It is an excellent, inexpensive magnesium source for acid soils. Use either calcitic or dolomitic limestone when the magnesium in the soil exceeds 100 ppm.

Limestone Quality

Two main factors affect the ability of limestone to reduce soil acidity. *Neutralizing value* is the amount of acid a given quantity of limestone neutralizes when it dissolves totally. Neutralizing value is expressed as a percentage of the neutralizing value of pure calcium carbonate. A limestone that neutralizes 90% as much acid as pure calcium carbonate has a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the less needs to be applied.

Fineness rating describes the limestone's particle size. The more finely ground the limestone, the greater its acid neutralizing ability. Limestone rock has much less surface area than finely powdered limestone and neutralizes soil acidity much more slowly.

Agricultural Index

OMAFRA uses the Agricultural Index to compare the acid neutralizing effectiveness of different limestone samples. Lime with a high Agricultural Index rating is worth more than lime with a lower rating because a smaller quantity achieves the same result. For example:

If ground limestone A has an Agricultural Index of 50, while ground limestone B has an Agricultural Index of 80, the application rate of A must be 80/50 times the application rate for B to achieve the same effect. Limestone A is worth 50/80 times the price of limestone B per tonne.

OMAFRA soil test recommendations assume an Agricultural Index of 75. Calculate the correct application rate for limestone of different quality using this formula:

Calculating Limestone Application Rates

$$\text{application rate} = \frac{75}{\text{Agricultural Index}} \times \text{application rate from soil test}$$

Raising Soil pH

Use lime to raise pH when it is indicated by soil testing. General lime application rates for most crops, based on soil pH and buffer pH, appear in Table 3–3, *Lime Requirements to Correct Soil Acidity Using Buffer pH*, on page 30.

Use Table 3–3 to determine how much lime is required to obtain the correct soil pH value.

TABLE 3–3. Lime Requirements to Correct Soil Acidity Using Buffer pH

Limestone needed (tonnes/hectare) based on an Agricultural Index of 75		
Buffer pH	**Target Soil pH = 6.5**	**Target Soil pH = 6.0**
	Lime if soil pH falls below 6.1	**Lime if soil pH falls below 5.6**
7.0	2	0
6.5	3	2
6.0	9	6
5.5	17	12
5.0	20	20

Tillage Depth

These lime recommendations should increase soil pH to the target value in the top 15 cm of the soil. If the soil is ploughed to a greater or lesser depth, proportionately more or less lime will be required to reach the target pH.

Lowering Soil pH

Lowering the pH of alkaline soils (pH > 7) is expensive, so acidifying large areas is impractical. In large fields with alkaline soils, consider growing crops that do not require acid soil.

Sulphur is the first choice for lowering pH if the starting soil pH value is 7 or less. Other acidifying materials (e.g., aluminum sulphate, iron sulphate) are less effective than sulphur and may be toxic to plants. Apply sulphur at least every other year to keep the soil pH near the desired level. Test the soil pH in the spring. If necessary, apply sulphur at the recommended rate (see Table 3–4, *Soil Acidification to pH 5.0 Using Sulphur*, on this page). In small areas, an alternative is to lower the soil pH by replacing the soil or amending it with large quantities of acid peat or another acidic organic material. Test the pH of any organic amendment before using it. Leaf mould, compost and peat may be alkaline rather than acidic.

Table 3–4 specifies the amount of sulphur that will help adjust soil to the correct ph value.

TABLE 3–4. Soil Acidification to pH 5.0 Using Sulphur

Elemental sulphur required (kg/100 m²) needed each year for two successive years		
Initial pH	**Soil Type**	
	Sand	**Loam**
7.0	7.4	22.6
6.5	6.0	17.5
6.0	4.0	12.0
5.5	2.0	6.0

Soluble Salts in Soil

High concentrations of water-soluble salts in the soil interfere with plant water uptake. This can delay or prevent seed germination, kill new transplants and seriously slow the growth of new and established plants. Levels of soluble salts can be tested by measuring electrical conductivity (EC). The EC measurement is expressed in units of millisiemens/cm (mS/cm). See Table 3–5, *Soil Electrical Conductivity (EC) Readings*, on page 31.

Ontario soils are naturally low in soluble salts. As a result, these salts rarely cause crop production problems and are not routinely measured in soil tests. However, excessive fertilizer application, road salt run-off and chemical spills can cause soluble salts to build up in the soil. This problem is most severe when soil moisture is low and salt concentrations are high. If salt problems are suspected, send a soil sample to an OMAFRA-accredited laboratory for analysis. Specifically request a soil EC reading. See *How to Sample Field Soil*, on page 26, for soil sampling instructions.

Table 3–5 interprets soil conductivity readings in Ontario field soils using a 2:1 water:soil paste mixture (based on volume).

TABLE 3–5. Soil Electrical Conductivity (EC) Readings

EC Reading (mS/cm)	Rating	Plant Response
0–0.25	Low	Suitable for most plants when using recommended amounts of fertilizer
0.26–0.45	Medium	Suitable for most plants when using recommended amounts of fertilizer
0.46–0.70	High	May reduce emergence and cause slight to severe damage to salt-sensitive plants
0.71–1.00	Excessive	May prevent emergence and cause slight to severe damage to most plants
> 1.00	Excessive	Expected to severely damage most plants

OMAFRA-accredited laboratories test for soluble salts by measuring the electrical conductivity (EC) of a soil/water slurry. The higher the concentration of soluble salts, the greater the soil's conductivity. If testing indicates a salt problem, correct it by leaching the soil with water.

Fertilizer Use

Fertilizing Field Nursery Stock

Fertilize nursery stock regularly to achieve optimum growth and maximum profit. Dry and liquid fertilizers produce similar results, so choose a suitable fertilizer formulation on the basis of soil test results, consistent supply, handling equipment available, application cost and cost per kilogram of nutrients. Use Tables 3–8 to 3–10, on page 33, when choosing fertilizer formulations.

OMAFRA provides reliable soil test recommendations for phosphorus and potassium. See Table 3–6, *Phosphorus Requirements for New and Established Field Nursery Stock*, on page 32 and Table 3–7, *Potassium Requirements for New and Established Field Nursery Stock*, on page 32. Field soil nitrogen levels fluctuate rapidly, making nitrogen soil tests unreliable.

Fertilizing Seed Beds and Transplant Liner Beds

Before planting beds in the spring, incorporate about 50 kg of actual nitrogen per hectare. Additional nitrogen may be required when planting particularly rapid-growing species. Add organic matter, such as rotted barnyard manure or compost, at a rate of about 45 t/ha. Growing green manures on the land provides another good source of organic matter. Adjust rates of nitrogen fertilizers if manure is applied. See Table 3–14, *Manure Application Rate and Approximate Nutrients Supplied* on page 42. When fresh, undecomposed organic matter that is low in nitrogen is added to soil, incorporate nitrogen to compensate for microbial decomposition. For example, use 15 kg of actual nitrogen per tonne of fresh sawdust. When preparing seed and liner beds, incorporate phosphorus and potassium as indicated by a soil test. In early spring of the second season, apply phosphorus and potassium as indicated by a soil test and apply nitrogen at the rate of 50–75 kg/ha.

Fertilizing Established Field Stock

Fertilize established field stock based on phosphorus and potassium soil test recommendations. See Table 3–6 and Table 3–7 on page 32. As noted earlier, field soil nitrogen levels fluctuate rapidly, making nitrogen tests unreliable.

Apply fertilizer in the spring, 1–2 weeks before growth resumes (just before bud break or as the first flush emerges).

Do not apply high rates of nitrogen after mid-July to avoid stimulating succulent growth in the fall. Apply small amounts of nitrogen regularly throughout the growing season or via a slow-release formulation.

Use Table 3–6 as a guide to the phosphorus requirements of new and established plantings based on soil test values.

TABLE 3-6. Phosphorus Requirements for New and Established Field Nursery Stock

Phosphorus (0.5 N sodium bicarbonate extractant)

Soil Test Value (ppm)	Response*	Phosphate (P_2O_5) Required (kg/ha)	
		New Planting	Established Planting
0–3	HR	140	100
4–5	HR	130	90
6–7	HR	120	80
8–9	HR	110	70
10–12	HR	100	70
13–15	HR	90	60
16–20	MR	70	50
21–25	MR	60	40
26–30	MR	50	30
31–40	MR	40	20
41–50	LR	0	0
51–60	RR	0	0
61–80	NR	0	0
80+	NR	0	0

*Explanation of ratings:

Response Category	Probability of Profitable Response to Applied Nutrients
High Response (HR)	High (most of the cases)
Medium Response (MR)	Medium (about half the cases)
Low Response (LR)	Low (few of the cases)
Rare Response (RR)	Rare (very few of the cases)
No or Negative Response (NR)	Not profitable to apply nutrients

Use Table 3–7 as a guide to the potassium requirements of new and established plantings based on soil test values.

TABLE 3–7. Potassium Requirements for New and Established Field Nursery Stock

Potassium (1 N Ammonium nitrate)

Soil Test Value (ppm)	Response*	Potash (K_2O) Required (kg/ha) (New or Established Planting)
0–15	HR	130
16–30	HR	120
31–45	HR	110
46–60	HR	100
61–80	HR	90
81–100	HR	80
101–120	MR	70
121–150	MR	60
151–180	MR	40
181–210	LR	0
211–250	RR	0
250+	NR	0

*Explanation of ratings:

Response Category	Probability of Profitable Response to Applied Nutrients
High Response (HR)	High (most of the cases)
Medium Response (MR)	Medium (about half the cases)
Low Response (LR)	Low (few of the cases)
Rare Response (RR)	Rare (very few of the cases)
No or Negative Response (NR)	Not profitable to apply nutrients

Use Table 3–8 to identify the Nitrogen content of common fertilizer formulations.

TABLE 3–8. Nitrogen Sources

Nitrogen Materials	% Nitrogen (N)	Other Elements Supplied
Ammonium nitrate	34	
Urea	46	
Calcium ammonium nitrate	27	4%–6% Calcium (Ca), 0%–2% Magnesium (Mg)
Ammonium sulphate	21	24% Sulphur (S)
Calcium nitrate	15	19% Calcium (Ca)
Potassium nitrate	12	44% Potash

Use Table 3–9 to identify common sources of phosphorus.

TABLE 3–9. Phosphorus Sources

Phosphorus Materials	% P_2O_5	Other Elements Supplied
Superphosphate	20	20% Calcium (Ca), 12% Sulphur (S)
Triple superphosphate	44–46	21% Calcium (Ca)
Monoammonium phosphate (11-52-0)	48–52	11% Nitrogen (N)
Diammonium phosphate (18-46-0)	46	18% Nitrogen (N)

Use Table 3–10 to identify common sources of potassium.

TABLE 3–10. Potassium Sources

Potassium Sources	% K_2O	Other Elements Supplied
Potassium chloride (muriate)	60–62	
Potassium sulphate	50	18% Sulphur (S)
Sulphate of potash magnesia	22	11% Magnesium (Mg), 20% Sulphur (S)
Potassium nitrate	44	12% Nitrogen (N)

Fall fertilization can be a great opportunity for increasing nitrogen uptake and plant growth. Spring growth after fall fertilization usually exceeds growth of those plants that were fertilized during the spring of the same season. Apply up to one-third of the year's fertilizer requirement after top growth ceases and the danger of top growth stimulation has passed (mid-September to mid-October). Roots of most nursery crops will grow and absorb nutrients whenever soil temperatures stay above 5°C. Nitrogen is either used quickly or lost through leaching. By splitting the total annual amount of nitrogen over several applications, losses can be minimized. A total of 100–150 kg of actual nitrogen per hectare can be used in one year. Rapid-growing species may need more nitrogen during particular growing conditions.

Use Table 3–11, in conjunction with Tables 3–8 to 3–10, to determine how much fertilizer will supply a given quantity of elemental nitrogen per specified area when the percentage of nitrogen in the fertilizer formulation is known.

TABLE 3–11. Nitrogen Equivalency Table

% Nitrogen in the Fertilizer	Kilograms of Fertilizer Needed to Supply:		
	0.5 kg of actual nitrogen/100 m^2	50 kg of actual nitrogen/ha	100 kg of actual nitrogen/ha
5	10	1,000	2,000
6	8.33	833	1,667
7	7.14	714	1,429
8	6.25	625	1,250
9	5.55	556	1,111
10	5.00	500	1,000
11	4.55	455	909
12	4.16	417	833
13	3.84	385	769
14	3.57	357	714
15	3.33	333	667
16	3.12	313	625
17	2.94	294	588
18	2.77	278	556
19	2.63	263	526
20	2.50	250	500
21	2.38	238	476
22	2.27	227	455
23	2.17	217	435
24	2.08	208	417
25	2.00	200	400
26	1.92	192	385
27	1.85	185	370
28	1.79	179	357
29	1.72	172	345
30	1.67	167	333
31	1.61	161	323
32	1.56	156	313
33	1.50	152	303
34	1.47	147	294
35	1.43	143	286
46	1.09	109	217

Sandy soils need more nitrogen and potassium fertilizers than clay soils, for optimum fertility. When no soil test is available, apply 100 kg of actual nitrogen per hectare using a 3-1-2 ratio fertilizer. Do not apply fertilizer in late fall or winter. It will not be absorbed because of the cold soil temperatures and may be lost through run-off.

Use Table 3–11, *Nitrogen Equivalency Table*, on this page when determining how much fertilizer is required to apply a specific quantity of elemental nitrogen.

Fertilizing Landscape Plantings

Most soils have enough inherent fertility to grow plants. There is no need to fertilize thriving landscape plants. Fertilize based on soil test results, soil characteristics, type of plant and desired growth. Fertilizer helps plants establish after transplanting and improves plant vigour.

Trees growing in lawn areas benefit from fertilizers applied to the grass. Apply herbicide-free turf fertilizer at a rate slightly above the recommended rate for grass. Any complete, high-nitrogen fertilizer should be adequate for trees and shrubs. Most studies show that nitrogen improves plant growth more than phosphorus and potassium. Distribute the required amount of fertilizer evenly on the soil surface. Begin well beyond the dripline (as much as twice the distance from the trunk to the dripline). Extend the fertilizer inward to two-thirds the distance between the dripline and the trunk. If paving obstructs part of the area under the branch spread, reduce the quantity of fertilizer accordingly. For landscape plantings, apply nitrogen at 1.0–1.5 kg actual N per 100 m^2. Water thoroughly after application. Increase the applications rate in the case of low tree vigour, a long growing season and/or well-drained sandy soil.

Split fertilizer applications during the year. Apply fertilizer in the spring, shortly before bud break or as the first foliage flush emerges. Fertilize again in the fall after top growth ceases and the danger of growth stimulation has passed (mid-September to mid-October). Apply up to one-third of the annual amount in the fall. To prevent run-off, broadcast fertilizer applications should not be applied to frozen soils. **To avoid stimulating top growth into the fall, do not use large amounts of fertilizer with readily available nitrogen between mid-July and early September.**

If fertilizer is applied only once, use fertilizers with 60% or more of the nitrogen in slow-release form. This will ensure the nutrients become available slowly, with minimum leaching. Pressure injecting slow-release fertilizer into the soil is acceptable. Use the drill hole method of tree fertilization if the soil needs aeration or when it is important not to overstimulate the vegetation growing on the surface.

Fertilizer Application Rates

Use the following formula to determine the nitrogen application rate of any nitrogen fertilizer formulation:

$$\text{kg fertilizer per } 100m^2 = \frac{100}{\text{\% N in fertilizer}} \times (0.5 \text{ kg N}/100m^2)$$

To calculate kg of fertilizer/hectare, multiply the result by 100.

Organic Amendments to Soil

Organic Matter Content of Soil

Organic matter helps maintain soil structure, aeration and water penetration. Soil structure and aeration promote root development and plant growth, while rapid water penetration minimizes erosion. When organic matter breaks down and/or is lost through clean cultivation practices, replace it by adding organic amendments to the soil. Table 3–12, *Optimal Organic Matter Content in Agricultural Soils*, below provides guidelines for optimal organic matter content in agricultural soils.

TABLE 3–12. Optimal Organic Matter Content in Agricultural Soils

Soil Type	Optimum % Organic Matter
Sandy soils	2–4 +
Sandy loam soils	3–4 +
Loam soils	4–5 +
Clay loam soils	4–5 +
Clay soils	4–6 +

Cover Crops

Cover crops play a major role in soil management. They reduce erosion by providing a ground cover and improve or maintain the soil by adding organic matter. To get the most benefit, plant late-summer and fall cover crops promptly after harvest. While broadcast application and incorporation of cover crop seed can be used to establish cover crops, direct seeding or drilling will ensure faster and more even establishment.

The following table provides information on some of the more commonly used cover crops.

TABLE 3–13. Characteristics of Cover Crops Grown in Ontario

Species	Normal Seeding Time	Seeding Rate kg/ha	Nitrogen[1] Scavenging Potential	Over-wintering Characteristics	Potential Weed Problem from Volunteer Seed	Nematode Rating[2]	
						Lesion	Root-knot
Grasses							
Ryegrass	April to May or August to early September	13–17	moderate	annual & Italian: partial survival; perennial: overwinters	no	–	–
Spring cereals	mid-August to September	100–125	moderate to high	killed by heavy frost	no	+	–
Sorghum sudan	June to August	50	moderate to high	killed by frost	no	NH[2]	–
Pearl millet	June to August	9–10	moderate to high	killed by frost	no	NH[2]	NH[2]
Winter wheat	Sept to October	100–125	moderate to high	overwinters well	no	+	NH
Winter rye	September to October	100–125	moderate to high	overwinters very well	no	+[3]	NH
Legumes[4]							
Hairy vetch	August	20–30	low to moderate (fixes N)	overwinters	no	++	+
Red clover	March to April	8–10	low to moderate (fixes N)	overwinters	no	++	+++
Sweet clover	March to April	8–10	low to moderate (fixes N)	overwinters	no	–	–

Species	Normal Seeding Time	Seeding Rate kg/ha	Nitrogen[1] Scavenging Potential	Over-wintering Characteristics	Potential Weed Problem from Volunteer Seed	Nematode Rating[2]	
						Lesion	Root-knot
Non-legume broadleaves							
Buckwheat	June to August	50–60	moderate	killed by first frost	yes	+++	NH
Oilseed radish[5]	mid-August to early September	10–14	high	killed by heavy frost	yes	NH[2]	NH[2]

Nematode Rating Codes: – = poor or non-host; + = ability to host; NH = non-hosts

[1] *The potential for nitrogen uptake is influenced by seeding date, stand establishment and growing conditions. Winterkilled cover crops can accumulate significant amounts of nitrogen the preceeding fall. Overwintering cover crops will accumulate a greater portion of nitrogen in the spring. Nitrogen-fixing legumes are less efficient at taking up residual nitrogen.*

[2] *Varietal differences in cover crop species may affect nematode reaction.*

[3] *Rye whole season rating would be higher (+++).*

[4] *Some diseases caused by* Pythium *and* Phytophthora *can be more severe after legume cover cropping.*

[5] *Oilseed radish residues can be toxic or allelopathic to subsequent crops if the following crop is planted too closely after green manuring. Allow the green manure residues to break down or dessicate before planting the next crop.*

Grasses

Grasses have fine, fibrous root systems that are well suited to holding soil in place and improving soil structure. The most suitable grass species for cover crops are fast growing and relatively easy to kill (either chemically, mechanically or by winter temperatures). Grasses do not fix nitrogen, but they can scavenge large quantities of residual nitrogen left in the field after harvest.

Ryegrass (Annual, Italian or Perennial)

Ryegrass is direct seeded in the spring or from August to mid-September. It can also be seeded with a nurse crop in the spring or broadcast into corn in late June to early July with some success. Annual ryegrass gives the most top growth in the seeding year. It often heads 6–8 weeks after seeding. Italian ryegrass (a biennial) does not head in the seeding year, so top growth is considerably less. However, it has the largest, densest root system of the three types. Annual and Italian ryegrass usually suffer considerable winterkill, but part of the stand may survive. Perennial ryegrass normally survives the winter.

Cautions:

Establishment and growth of ryegrasses can be poor during very hot, dry weather. Cultivation or discing may not completely kill overwintering ryegrass. The nitrogen tied up in ryegrass releases more slowly compared to many other cover crops.

Spring Cereals (Oats, Barley, Spring Wheat, Etc.)

Spring cereals can be inexpensive, easy-to-manage cover crops. Stands seeded from mid-August to mid-September will have 20–40 cm of growth by freeze-up. Early-planted cover crops may produce seeds under warm, wet conditions, but little viable seed is usually set. Spring cereal cover crops are generally killed by late, hard frosts. Volunteer spring cereals are sometimes left to grow as a cover crop until freeze-up. These stands may not be very uniform. There is

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much less residue left by most winterkilled spring cereals, which can be beneficial for early planting.

Cautions:

Very early seeding may result in considerable growth by freeze-up. If left unploughed in the fall, the mat of dead residue will delay soil drying and warming in the spring, which may delay the planting of early-seeded crops. On erosion-prone knolls, spring cereals often have little growth and have been observed to "blow off" by spring.

Sorghum Sudan and Forage Pearl Millet

Sorghum sudan and forage pearl millet are warm-season grasses. They are extremely sensitive to frost. They have extensive root systems and produce a significant amount of top growth. They are both a good option for a mid-summer green manure crop after early-harvested vegetable crops such as peas, sweet corn or cucumbers.

Plant in mid-June, after all threat of frost is past, through to early August. These crops benefit from the warm temperatures of early to mid-summer. Applying approximately 50 kg of nitrogen per hectare will help the crop achieve maximum top growth. A preplant herbicide treatment is recommended to help establish the crop. Frost will control these grasses in early to mid-fall. If earlier control is needed, most burndown herbicides will be effective.

Planting certain cultivars of sorghum sudan (Sordan 79, Trudan 8) and forage millet in rotation with high-value horticultural crops can reduce plant parasitic nematode soil populations below economic thresholds. It may be necessary to grow these varieties under weed-free conditions for more than 1 year to be fully effective. These cover crops may not entirely replace fumigation under high levels of nematode pressure. However, they are useful in keeping nematode levels low and preventing resurgences in the future. Sorghum sudan and pearl millet do not have to be incorporated green for nematode suppression.

Canadian Forage Pearl Millet 101 reduces nematode populations by inhibiting the ability of nematodes to reproduce in its root system.

Cautions:

Mow before the crop reaches 1 m in height. This encourages root development and tillering and prevents the stalks from becoming woody and slow to decompose. To ensure regrowth, do not mow shorter than 15 cm.

Winter Rye

Winter rye is one of the most consistent, flexible and economical cover crops available. It can be seeded later than any other crop and still survive over winter. For good ground cover and erosion protection, it should be seeded at least a month before freeze-up. Typically, that means seeding it from September into late October. It grows until freeze-up and then begins growing again in late March to early April (slightly earlier than winter wheat). The growth rate is very rapid during May. Kill the stand with either tillage or a herbicide in late April or early May. Winter rye can be seeded earlier than September (without vernalization or the winter cold, it will not produce seed heads). However, the summer heat and common lack of soil moisture may result in an uneven stand.

Cautions:

Rye will grow very rapidly under warm temperatures in early spring, so monitor growth closely and kill the crop before it grows too tall. If rye is left too long, it can deplete soil moisture and incorporation may be difficult. Rye is an excellent host for root-lesion nematode, particularly when grown as a full-season crop.

Winter Wheat

Seed winter wheat from late August through October. It can be seeded outside this time frame, but weather conditions may reduce top growth. Wheat will survive over winter and begin growing again in April. The stand can be killed through tillage or herbicide application. Compared to rye, winter wheat shuts down earlier in the fall and begins to grow later in the spring.

Cautions:

Winter wheat does not generally provide the same amount of green material to return to the soil or the level of weed suppression that rye provides.

Early-planted wheat may be more susceptible to infection with the barley yellow dwarf virus (BYDV), although this will have little impact on growth of the wheat as a ploughdown or cover crop.

Legumes

Legume cover crops can fix nitrogen from the air, incorporating it into the soil for the succeeding crop. They also protect the soil from erosion and add organic matter. The amount of nitrogen fixed varies between species. Generally, more top growth indicates more fixed nitrogen. Legume cover crops, such as clover, are 80% as effective at scavenging soil nitrogen as grass cover crops. Some legume species have aggressive tap roots that can break up subsoil compaction, but this will require more than one season's growth.

Nitrogen release from legumes can be inconsistent because it is a biological process, affected by soil moisture and temperature. This must be accounted for when calculating fertilizer needs. Excess nitrogen release late in the season could lead to excessive vegetative growth in fruiting vegetables and may delay hardening off for winter.

Hairy Vetch

Hairy vetch must be seeded by mid-August to provide good ground cover over winter. Late seeding may result in winterkill. It grows slowly until freeze-up, establishing a very vigorous, fibrous root with moderate top growth. Hairy vetch may also be drilled into winter wheat when the wheat is about 20 cm tall. Seeding at this stage prevents the hairy vetch from causing a problem with wheat harvest but results in much more vetch growth by freeze-up compared to August seedings. Hairy vetch vines resume growth early in the spring (similar to the time for winter wheat) and may reach 150 cm in length if left to maturity. Cover crop stands are usually killed in the spring by tillage or herbicide application. Vetch's fibrous root system improves soil structure. It also adds large amounts of fresh organic matter to the soil.

Cautions:

Competition from volunteer cereals can lead to poor stands of hairy vetch. On droughty soils, hairy vetch may deplete soil moisture if it is left to grow until early May. Roundup does not kill hairy vetch effectively. Instead, use 2,4-D, MCPA, Banvel or their mixtures. If hormone-sensitive crops are to be planted, apply these sprays in the fall to avoid harming them. Hairy vetch is slow to establish and provide ground cover, leaving the soil open to erosion and weed seed germination.

Red Clover

While not commonly used in horticultural rotation, red clover is often broadcast into winter wheat in March or early April or seeded with spring cereals. Early seeding gives the best stands. Double-cut red clover is more resistant to dry summer conditions. It produces considerably more top growth than single cut (60 cm vs. 25 cm, respectively).

The bulk of red clover growth takes place from mid-summer until a heavy frost. Red clover can be killed in the fall or spring by tillage or herbicide application. Unless herbicides are also applied, chisel ploughing will not kill the stand completely. Red clover ploughdown improves soil structure and adds large amounts of organic matter. Nitrogen is fixed and released slowly to the following crop. It gives excellent erosion protection when left unploughed until spring or killed with a herbicide in the fall (but not tilled).

Cautions:

Roundup alone often doesn't kill red clover effectively. Instead, consider 2,4-D, MCPA, Banvel or mixtures. If hormone-sensitive crops are to be planted, apply these sprays in the fall to avoid harming them.

Sweet Clover

Similar to red clover, sweet clover is most commonly seeded into winter wheat in March or early April or seeded with spring cereals. Either yellow- or white-blossom type may be used. White-blossom type produces somewhat taller top growth.

The bulk of sweet clover growth takes place after the grain is harvested until heavy frosts. Top growth will usually be 30–40 cm tall, but not dense. A strong taproot is produced, often 30 cm long and 1 cm across at the crown. If allowed to grow the following

spring, sweet clover will flower in July at a height of about 180 cm, then set seed and die. Ploughdown stands may be killed in the fall or the following spring using tillage or herbicides, similar to red clover.

Cautions:

Sweet clover is very sensitive to many herbicides and will not tolerate any phenoxy herbicides, including 2,4-D.

Non-Legume Broadleaves

These broadleaf crops cannot fix nitrogen out of the air, but they may absorb large quantities from the soil. These crops are not winter-hardy, so additional control measures are not normally required. Do not allow these crops to go to seed, as the volunteer seed can become a significant weed problem.

Buckwheat

As a cover crop, buckwheat is most commonly seeded in late June to early August. It grows very rapidly, reaching flower stage and a height of 45–75 cm in about 6 weeks. It has a relatively small fibrous root system and is completely killed by the first frost. Buckwheat provides rapid soil cover and gives good erosion protection during the growing season. It smothers annual weeds and suppresses perennial ones. Moderate amounts of fresh organic matter are returned to the soil. Buckwheat does not fix nitrogen. It can be planted as a green manure crop, after early-harvested crops such as peas, snap beans and winter wheat. Buckwheat is often used in organic production systems as a rotation crop to help clean up weed infestations and make phosphorous more available.

Cautions:

The flowers are very attractive to bees. Monitor flowering and take appropriate action to prevent seed set. Late summer seedings may be killed by an early frost before providing significant growth.

Oilseed Radish and Mustard

Oilseed radish is commonly seeded in August or very early September. It is unaffected by early frosts. It can grow to a height of 50–90 cm and blooms in October. If planted too early, the flowers may set seed. Mowing oilseed radish before it flowers will delay seed set while maintaining cover. Leave 10–15 cm of cover crop height to encourage regrowth. The plant has a thick taproot, varying between carrot-shaped and turnip-shaped, with extensive secondary roots. Oilseed radish is killed by freezing in late November or December. It provides a reasonably rapid soil cover and excellent erosion protection over winter. It returns moderate amounts of organic matter to the soil. To ensure good crop growth, make sure the soil contains a large amount of available nitrogen, either from a recent manure application or left over from a previous crop.

Some oilseed radish (and certain mustard) cultivars can help to reduce plant parasitic nematode populations in the soil. The nematode-suppressing cultivars must be incorporated into the soil while they are still green. As the green residue breaks down, it releases a nematode-killing compound (isothiocyanate) into the soil.

Cautions:

Growth will be poor if soil nitrogen levels are low or soil compaction is severe. Scattered volunteer plants usually appear in most crops planted after oilseed radish. To successfully reduce nematode population levels below the economic thresholds, these crops may need to be planted for more than 1 year.

The mild winters of southwestern Ontario may allow some varieties of oilseed radish and mustard to partially overwinter.

For more detailed information on cover crop use and management, see the OMAFRA website at www.ontario.ca/crops.

Tillage Systems After Cover Crops

In conservation and no-till cropping systems, cover crops can greatly increase the surface residue cover, adding to the potential benefits of the system.

However, there are several management factors to keep in mind:

- Some regrowth of winter annual, biennial or perennial cover crops may occur in the following crop year. Usually this is easily controlled with

normal herbicide treatments in the following crop. Allowing a controlled amount of regrowth (for example, windstrips) can provide some spring wind protection.

- The first conservation tillage operation with overwintering cover crops should occur at least 2 weeks before planting the main crop. This will allow the breakdown of the residue to start.
- Seedbed preparation may be difficult if persistent cover crops are not tilled until spring or if they are allowed to grow too large.
- Cover crops that do not survive over winter may be an option, especially on poorly drained soils or for crops that are planted very early in the spring.
- Burndown herbicides should be considered before conservation tillage of overwintering cover crops such as rye. Careful timing, rate and application of herbicides can help keep enough residue on the surface to prevent wind damage to tender crops while they get established.

For more information, see:

- ***Soil Fertility Handbook*, OMAFRA Publication 611**
- ***Best Management Practices: Managing Crop Nutrients*, Order No. BMP20E**
- ***Best Management Practices: Soil Management*, Order No. BMP06**
- ***Best Management Practices: Field Crop Production*, Order No. BMP02**
- ***Best Management Practices: Nutrient Management*, Order No. BMP05**

Applying Manure

Applying manure to fields provides many benefits. It adds organic matter to the soil and supplies many of the nutrients needed for crop production. It increases moisture retention and internal drainage. It also builds structure, increases stability and provides a source of nutrients that supports a diverse biological population in the soil. Keep in mind, however, that many fields require more nitrogen than manure alone can supply.

Store manure in a way that saves the liquid portion and minimizes exposure to air. Do not spread manure in winter or early spring on fields subject to run-off. For best results, apply manure in the late fall or spring. Incorporate manure into the soil within 24 hours of application to prevent nitrogen loss. Waiting more than 24 hours can reduce nitrogen levels by about 25%.

If manure is applied in the fall or winter, large amounts of nitrogen will be lost through leaching. OMAFRA nitrogen adjustment tables (see Table 3–14 on page 42) assume the manure will be applied in the spring. The nutrient content of manure depends on a variety of factors such as livestock type, age and rations, as well as how the manure is stored and whether water is added.

Sampling Manure

It is important to know the nutrient content of manure in order to decide on how much to apply. This means sending samples to a laboratory for testing. Make sure the manure is sampled correctly, however. For liquid manure, mix the tank contents thoroughly before taking a sample. For solid manure, take forkfuls from many places in the stack, not just from the surface. Mix these samples thoroughly, and then submit 1–2 kg for testing.

Timing of Manure Applications

Manure is made up of two main sources of nitrogen. The readily available mineral nitrogen comes in the form of ammonium. This is a positively charged ion that binds to soil particles and is unlikely to be leached. Generally, if the soil is 10°C or colder, very little ammonium will be converted to nitrate-nitrogen, which can be lost through leaching. This is the reason that manure applied in the late fall is more environmentally friendly than manure applied in early fall.

The other source of nitrogen is slowly available nitrogen, which comes in an organic form that is bound to carbon. Organic nitrogen is released slowly over time, as a function of temperature and soil aeration.

Table 3–14 offers guidance on manure application rates and resulting fertilizer reductions. Each batch of manure is unique and should be tested for accurate nutrient information.

TABLE 3–14. Manure Application Rate and Approximate Nutrients Supplied

Class of Livestock	Nitrogen (kg/ha)			Phosphate	Potash
	Fall	Spring[1]	Spring C[1]	P_2O_5 (kg/ha)	K_2O (kg/ha)
Liquid manure at 10 m3/ha (900 gal/acre)					
Cattle and mixed livestock	5	10	12	4	16
Poultry	23	46	58	22	26
Swine	8	15	19	7	14
Solid manure at 10 t/ha (4.5 tons/acre)[2]					
Cattle and mixed livestock	12	24	30	10	44
Poultry	70	140	175	75	96
Swine	15	30	38	20	26

[1] *Spring is spring-applied manure not covered immediately; Spring C is spring-applied manure covered within 1 day or injected.*

[2] *Density of manure in spreader may vary from 400 kg/m³ (25 lb/ft³) for heavily bedded or very dry manure to 1,000 kg/m³ (62 lb/ft³) for semi-solid and liquid manures.*

Container Production

Using Containers

High-density plastic pots are most commonly used for long-term container growing. Fibre pots are useful for short-term growing, for potting of field-grown stock and for winter storage or spring shipping. Fibre pots are not recommended for long-term growing because they soften, decompose and may be damaged by rough handling. Always remove a fibre pot when planting in the landscape. Recently, growers are testing alternative materials for pots, most notably coco coir. These pots have the added benefit of increasing aeration porosity (the percentage of air in the pore space) in the root zone and, in many cases, they can be composted.

Pot colour affects mix temperature and root development. Root growth decreases when media temperatures approach 30°C. Studies show that black and dark green pots may be 10°C hotter than white or light-coloured pots. The temperature of dark pots may reach almost 40°C on the inner surface of the sunny side. However, white or light-coloured pots are not widely available unless ordered in large quantities from the manufacturer. Use light-coloured pots along the outside rows of a block and for widely spaced plants. Dark colours in the centre of a pot-to-pot block are acceptable, as sunlight will not strike the pot wall. To diagnose high-temperature injury, remove the pot and compare root growth on the sunny and shaded sides of the pot.

Root circling, especially in small circular containers, can result in root constriction and eventual plant decline. Minimize root circling by using square containers or ones with vertical ribs. Tree species in small containers are particularly vulnerable to root circling. Air circulation at the base of the container encourages air pruning and root branching. Re-pot plants before the roots become "pot-bound." Check

for circling roots and remove them when re-potting. Prune the roots of pot-bound plants to discourage root circling after re-potting or planting.

Staking the outside rows of container crops can help prevent plants from blowing over, especially tall plants.

Potting Media

A successful container-growing operation depends on the potting media. The media ingredients need to be free of insects, diseases and weeds, readily available (to ensure a continuous supply) and reasonably priced. Traditionally, growers have used peat combined with equal amounts of concrete-grade sand. However, this media becomes alkaline if the sand has a high pH, and aeration can be too low. Composted bark provides good aeration when mixed with peat. Mixes such as 2 parts bark to 1 part peat or equal parts bark and peat to 1 part sand provide adequate aeration and water-holding capacity. Composted bark may also help to suppress root disease organisms in the root zone.

Well-decomposed coarse sawdust is a useful media ingredient. Avoid fresh sawdust due to its very high carbon:nitrogen (C:N) ratio. Generally, the higher the C:N ratio, the slower the material will decompose. The C:N ratio of fresh sawdust is 1,000:1, of conifer bark 300:1 and of hardwood bark 150:1. Materials with high C:N ratios need large amounts of nitrogen to break down. Therefore, the breakdown of fresh sawdust can actually rob nitrogen from the media. To compensate for a high C:N ratio and enhance decomposition, add 1 kg of actual nitrogen (e.g., 3 kg ammonium nitrate, 34-0-0) per cubic metre of bark.

Adequate aeration is vital. Since roots require oxygen to grow properly, a poorly aerated mix will restrict root growth. Water-holding ability is also important, though secondary to aeration. Avoid overmixing the ingredients of soilless media as it will lead to reduced aeration. Mixing for more than 5 minutes may actually break down coarser materials and produce more "fines" that will plug pore space in the media. This will result in a mix with low aeration porosity and drainage.

Using Soilless Media

Soilless media differ greatly from field soils both chemically and physically. Slight changes in media components (source, ratio, etc.) can have significant effects on porosity and drainage. Management practices such as watering and fertilizing will also have a signifcant impact on media performance. Always test media performance by trying the media on a small block of plants first.

Much of the soilless container media used in Ontario is a mixture of composted bark (50%–65%), sphagnum peat (30%–40%) and other composted waste (up to 10%). Inorganic compounds such as perlite or vermiculite may also be added to improve aeration. Peat and bark-based media have good aeration and moisture-holding properties but limited nutrient-holding capacity. Coco coir may be used to increase the aeration porosity of the media.

Manage fertility closely to achieve maximum crop growth potential. High pH affects the availability of most micronutrients. Therefore, avoid growing media with a pH of more than 6.5. High pH values caused by adding coarse sand may lead to low levels of iron or manganese and poor crop growth.

For more information about soilless growing media, see OMAFRA Publication 370, *Production Recommendations for Greenhouse Floriculture.*

Determining Media Porosity

Adequate aeration is vital. Water-holding ability is also important, though secondary to aeration. Since roots require oxygen to grow properly, a poorly aerated media will restrict root growth and actually lead to root death. As container mixes are handled and used for production, organic matter is broken down, resulting in finer particle sizes. These fine particles can interfere with drainage and aeration by plugging up pore spaces in the media. The media will also become compacted over time. Reduced levels of aeration and drainage will decrease the amount of oxygen available to plant roots. The result is root dieback and root disease. Avoid problems with media by measuring aeration porosity and re-potting plants regularly throughout the production cycle. For more information, contact the OMAFRA Nursery Crops Specialist.

When considering a new media, test the new media in a small portion of the crop. Compare plants grown in standard potting mix with plants grown in a new one to select the best media.

The total porosity of a mix is the space between mix particles that air or water can potentially fill. The aeration porosity of a mix is the percent of space filled by air after irrigation water has drained out. Aim for a total porosity value above 50% and an aeration porosity beween 15% and 30%. Too much aeration will not harm the plants, but the media will require frequent irrigation. A potting mix with a high percentage of particles smaller than 0.5 mm results in low aeration porosity and poor drainage. For pine and yew, use mixes with an aeration porosity of 20%–25%. Juniper and white cedar can tolerate lower aeration porosity values.

To determine media porosity, the grower will need:

- the average growing pot (#1, #2, etc.)
- a method to cover or plug the pot drain holes (e.g., plastic bag inside pot)
- graduated cylinders (large and small) or other containers designed for measuring liquids
- some dry potting mix

To calculate the porosity of the potting media, follow these steps:

1. Cover or plug the drain holes of the pot.
2. Fill the pot with water to the normal level of the potting media. Pour this water into the graduated cylinder (or other measuring containter) and record the volume of this water. This amount of water is the total volume of the pot [A].
3. Make sure the drain holes are still plugged, and then fill the pot with slightly moist media to the normal level of the potting media. Make sure that the pot is level.
4. Slowly add a measured volume of water to the media until a water slick appears on the surface. The volume of water added is the pore volume of the media [B]. Record this number.
5. Without moving the pot, remove the drain hole covers or plugs. Let the water drain into a bucket, then measure the volume of water that drained. This is the aeration pore volume [C]. Record this number.
6. Calculate the media porosity using the following formula:

Media porosity formula

Total porosity (%)	=	(B / A) x 100	
Aeration porosity (%)	=	(C / A) x 100	
Water retention porosity	=	Total porosity	– Aeration porosity

Sample Calculation:

[A] Total container volume	= 5,180 mL
[B] Pore volume (water added to saturate the media)	= 3,354 mL
[C] Aeration pore volume (water drained from container)	= 1,080 mL

$$\text{Total porosity} = \frac{(3{,}354) \times (100)}{5{,}180} = \mathbf{65\%}$$

$$\text{Aeration porosity} = \frac{(1{,}080) \times (100)}{5{,}180} = \mathbf{21\%}$$

Water retention porosity = 65% – 21% = **44%**

Adjusting Potting Mix pH

It is important to maintain the right pH for container crops. Here are some key points to remember:

- Maintain a potting mix pH between 5.5 and 7.0. High levels of bicarbonates in Ontario irrigation water can significantly raise media pH over the growing season.
- Do not use alkaline sand in the mix when growing pH-sensitive crops.

- Acidifying fertilizers may help to prevent pH from climbing too high. When using injectors, apply fertilizer and acid concentrates as separate solutions.
- Irrigation water can be acidified with nitric or phosphoric acid, depending on the bicarbonate content of the water. For more detailed information on acidifying irrigation water, see Chapter 3, Water, Growing Media and Crop Nutrition, in OMAFRA Publication 370, *Production Recommendations for Greenhouse Floriculture*.
- *Juniperus* and *Thuja* will grow adequately at a higher pH, but plants such as *Syringa*, *Rhododendron* and *Taxus* will exhibit iron and/or manganese chlorosis if the pH is above 7.0.

Fertilizing Container Stock

Most container mixes contain little or no soil, resulting in low fertility. Apply water-soluble or controlled-release fertilizers to correct this problem.

Fertilizers affect the environment, especially the groundwater. Organic substrates, such as peat and bark, are generally negatively charged. This means that they repel negatively charged molecules, such as nitrates and phosphates. As a result, nitrates and phosphates leach easily from most container substrates.

To help reduce impacts on the environment and maximize the efficiency of a fertilizer program, take measures to reduce leaching from containers. Reduce the amount of irrigation water used for delivering water-soluble fertilizers and collect irrigation and leachate water run-off for re-use.

How to Sample and Test Container Media

In general, organic substrates are low in fertility. This makes regular media testing a vital part of successful container production. Sample every 2 weeks. Once a pattern of nutrient levels has been established, monitoring can be limited to testing every 2 weeks for pH and soluble salt (EC) readings, along with an occasional nutrient analysis. For more information about measuring media pH and EC, see OMAFRA Publication 370, *Production Recommendations for Greenhouse Floriculture*.

Here are some key points to remember:

- Use a small-diameter sampling probe to sample container-grown stock. To obtain a sample, remove the pot and take a core through the medium, midway between top and bottom and midway between the stem and the edge of the pot.
- Take samples from at least 10 pots and then mix them to get one pooled sample of media for testing. A pooled sample will better represent the nutrient status of media in that block. To reduce the impact on the root systems, take smaller media samples from a greater number of pots. Some horticulturalists remove fertilizer prills from the media samples, while others include them. Either approach is fine. Choose one and stick with it, however, since it is important to be consistent with media sampling protocols.
- Refrigerate the sample until it can be delivered to the lab.
- If water-soluble fertilizer is applied continuously, sample the soil 30 minutes after application.
- If a dry surface fertilizer (granular or pellet) is used, always sample before adding the fertilizer. Insert the probe carefully, avoiding any surface fertilizer residue.
- When both are applied at recommended rates, water-soluble fertilizers normally produce lower salt concentrations than preincorporated controlled-release fertilizers.
- Analyze all soil samples from container potting mixes at an OMAFRA-accredited laboratory using a saturated paste analysis for greenhouse media. Compare these test results with previous samples and with the ranges in Table 3–15, *Media Nutrient Levels for Most Container Crops*, on page 47, to determine trends in pH, EC and nutrient status. Analysis results can then be correlated with plant growth and health symptoms to help establish thresholds for irrigation water and media test results.

- Garden centres must continue controlling the fertility of container-grown plants to ensure proper growth, especially with plants grown previously using liquid fertilizers. Add a controlled-release fertilizer according to the manufacturer's recommendation. Do not add fertilizer on the surface before shipping.

Using Water-Soluble Fertilizers

Apply water-soluble fertilizers through a low-volume irrigation system using an accurate concentrate diluter or injector. Under conventional overhead irrigation, water-soluble fertilizers can be lost in between pots and leach quickly from container media. Unless all the run-off is collected, the fertilizer salts can move to underlying soils and groundwater systems, creating environmental problems. To reduce the amount of leached salts, reduce fertilizer rates and reduce the amount of water passing through the media (e.g., pulse or cyclic irrigation).

In theory, soluble fertilizers are applied at every watering. However, this may not be the most efficient use of fertilizer. Testing shows that intermittent fertilizing results in similar levels of plant growth compared to constant fertilizing.

When water-soluble fertilizers do not contain micronutrients, add these to the mix before potting or as soluble trace elements during the growing season. Composted waste materials are quite often a good source of micronutrients. Dry materials with added bulking agents are less concentrated, making them easier to blend into the mix. Use these as recommended by the manufacturer.

Commercial water-soluble fertilizers come in various analyses (e.g., 24-10-20 or 28-14-14). Use them at the rate of up to 200 ppm nitrogen (i.e., up to 83 g of 24-10-20 per 100 L of water).

Avoid the use of water-soluble fertilizers on media with low aeration porosity. Watering to fertilize may cause poor growth due to low aeration. Controlled-release fertilizers may be a better choice.

Using Controlled-Release Fertilizers

Controlled-release (encapsulated) fertilizers work well with container stock. Incorporate controlled-release fertilizers into the potting mix or top-dress with them later. Use as suggested by the manufacturer. Incorporating controlled-release fertilizers can actually prolong the release pattern of the product and improve plant growth over the season compared to top dressing. Incorporating controlled-release fertilizers can also prevent spillage losses that are common with top dressing.

Avoid excessive mixing when preparing a potting mix. This may break fertilizer particles, which can cause problems due to excessive salt. Do not store potting mixes with preincorporated, controlled-release fertilizers for an extended time period.

Several controlled-release fertilizer formulations now contain micronutrients. When controlled-release fertilizers do not contain micronutrients, add these according to the manufacturer's recommendation. Supplemental fertility, particularly nitrogen, may benefit fast-growing crops when using controlled-release fertilizers. In container media, nitrate-nitrogen levels can be determined using the Greenhouse Media tests. Apply water-soluble forms of nitrogen to the plants at the rate of 150–200 ppm of actual nitrogen whenever soil tests show nitrogen values under 39 ppm.

TABLE 3–15. Media Nutrient Levels for Most Container Crops

Nutrient Concentration		What to Do
Nitrogen (as water-soluble nitrate-nitrogen NO_3N)		
Low	0–39 ppm	Add extra nitrogen to the feeding program, especially if using slow-release materials.
Normal	100–199 ppm	Continue feeding at high levels and check total salts.
Excess	250+ ppm with high salts	Discontinue feeding nitrogen and check total salts as root damage may occur. Higher rates of nitrogen may be needed for optimum growth in a bark mix and to maintain the same soil test level as in a peat mix.
Phosphorus (as water-soluble P)		
Low	0–2 ppm	Add additional phosphorus to the feeding program.
Normal	6–9 ppm	Continue feeding at high levels and check total salts.
Excess	50+ ppm	Discontinue feeding phosphorus.
Potassium (as water-soluble K)		
Low	0–59 ppm	Add additional potassium to the feeding program.
Normal	150–250 ppm	Continue feeding at high levels and check total salts.
Excess	350+ ppm	Discontinue feeding and leach. Plants may tolerate higher levels if the mix contains a high proportion of organic material. (Leaching is ineffective for removing controlled-release fertilizer that has been incorporated in the media.)
Soluble salts (EC) in mS/cm (mhos x 10^{-3}/cm)		
Low	0.75–2.0	Check for adequate nitrogen and potassium levels.
Normal	2.0–3.5	Continue the feeding program.
Excess	3.5+	Discontinue feeding. Plants may tolerate higher levels if the mix contains a high proportion of organic material.
Calcium (as water-soluble Ca)		
Low	0–79 ppm	Add extra soluble calcium to the feeding program. (Calcium levels are easily raised by adding dolomitic lime or gypsum to the media.)
Normal	200–300 ppm	
Excess	400+ ppm	Consider reducing the use of fertilizers with significant sources of calcium (e.g. lime, gypsum or soluble calcium)

TABLE 3–15. Media Nutrient Levels for Most Container Crops *Continued*

Nutrient Concentration		What to Do
Magnesium (as water-soluble Mg)		
Low	0–29 ppm	Apply 0.5 kg/1,000 L of magnesium sulphate through the irrigation water.
Normal	70–200 ppm	
Excess	200+ ppm	Consider reducing the use of fertilizers or other products with significant sources of magnesium (e.g. dolomitic lime or soluble magnesium)
Miscellaneous		
Sulphate levels should not exceed 300 ppm.		
Chloride levels should not exceed 50 ppm.		
pH should fall between 5.0 and 6.5.		

Check soil test values in early July of the second growing season after using preincorporated controlled-release materials. Necessary nutrients can be supplied with water-soluble fertilizers through the irrigation system or through surface fertilizer applications. Some controlled-release materials are rated to provide nutrition for two growing seasons.

Controlled-release fertilizers may produce inconsistent soil test results if prills break during sampling, shipping or testing. Some horticulturalists will remove prills before mixing and testing of media samples, especially if the prills are at the beginning of their release pattern. It is important to be consistent with media sampling protocols. It is also helpful to take notes about the sampling block (age of media, fertilizer dates, age of plants, etc.).

Measuring Nutrient Levels in Container-Grown Crops

It is important to sample media correctly. See *How to Sample and Test Container Media*, on page 45, for sampling instructions.

Woody plants use nitrogen both in the form of nitrates and ammonium. Under most summer conditions, ammonium nitrogen converts quickly to nitrate-nitrogen due to micro-organism activity. Current container media tests measure nitrate-nitrogen. However, ammonium nitrogen can be measured on request. Controlled-release fertilizers may produce inconsistent media test results if capsules break during sampling, shipping or testing. OMAFRA-accredited laboratories report container media nutrients in parts per million (ppm). Monitor crops for growth and plant health, and compare media tests with with nutrient levels listed in Table 3–15 on page 47. For more information, see OMAFRA Publication 370, *Production Recommendations for Greenhouse Floriculture.*

Irrigation Water

Water Quantity

The use of irrigation water for nursery crops usually peaks in late spring and summer. This is also the period of peak water use for most other agricultural operations. Nursery growers must conform to the Ministry of the Environment (MOE) regulations regarding daily usage of water. The taking of water in Ontario is governed by the *Ontario Water Resources Act* (OWRA) and the *Water Taking and Transfer Regulation* (Regulation 387/04). Section 34 of the OWRA requires anyone taking more than a total of 50,000 L of water in a day from a lake, stream, river or groundwater sources, including spring-fed ponds,

to obtain a permit from the MOE to take water. All permit holders must collect and record the volume of water taken daily and report this data annually to the MOE. Water conservation is an important part of MOE's Permit to Take Water program. When making an application for a permit, document current or proposed conservation measures.

- **For further information, see Ministry of Environment's *Permit to Take Water Manual*, the *Guide to the Permit to Take Water Application Form* and other related Factsheets online at http://www.ene.gov.on.ca/envision/water/pttw.htm.**
- **Also see *Best Management Practices: Irrigation Management*, Order No. BMP08E.**

Water Quality

Irrigation water quality is one of the most important components of a growing system, yet it is often overlooked. Irrigation water has a significant influence on the characteristics of the media, media solution and the nutrient solution. Over successive irrigation cycles, the chemical properties of the water affect the pH, soluble salts, bicarbonate level and other chemical properties of the media and media solution. The media in smaller pots is affected more quickly than in larger pots, due to the reduced buffering capacity of the smaller volume. The effects on media will, in turn, affect plant growth. Common symptoms of water-quality problems may include nutrient deficiency symptoms such as interveinal chlorosis suggesting improper pH, leaf margin browning and poor root growth due to accumulation of salts.

The pH of the water does not give a true sense of alkalinity. Alkalinity actually refers to the water's ability to resist changes in pH. This influenced by the concentration of calcium carbonate ($CaCO_3$) or bicarbonate (HCO_3) dissolved in the water. Most southern Ontario soils have a limestone base, which gives both the soil and the underlying groundwater their alkalinity. Because of this, well water and other sources of groundwater usually have a higher pH or alkalinity than surface water. High levels of bicarbonates in the irrigation water will lead high pH levels in the media and media solution. Since pH significantly influences availability of nutrients in soilless media, a pH higher than 7 may create deficiencies of iron, manganese and zinc.

High levels of bicarbonates in irrigation water make it more difficult to lower the pH to an acceptable level for growing plants. Although acidifying fertilizers (those that contain ammonium nitrogen and sulphur) can help reduce the level of bicarbonates, acid injection may be the only effective solution for very alkaline water. High levels of bicarbonates and high pH can be corrected by injecting nitric or sulphuric acid or a combination of both. If acid is used to correct water pH, make sure the injector is rated to handle acid. The volume of acid that needs to be added depends on the bicarbonate level of the water. For more information on water quality and correcting pH, see Chapter 3, Water, Growing Media and Crop Nutrition, in OMAFRA Publication 370, *Production Recommendations for Greenhouse Floriculture.*

Soluble salts in irrigation water can also significantly affect plant growth. Soluble salts are measured as Electrical Conductivity (EC). The soluble salts of most concern in irrigation water are sodium, chloride and sulphates. Just like pH, the EC of the irrigation water has a direct effect on the EC of the media and media solution. High EC in the media solution can be the result of over-fertilizing or using poor-quality irrigation water. Either way, it can interfere with root uptake and may lead to root damage and death. Symptoms of high soluble salts include small, dark-green leaves, wilting (even when the media is wet), marginal leaf necrosis, stunting and death, depending on the severity. If the EC of irrigation water is higher than the suggested ranges (see Table 3–16, *Acceptable Ranges for Chemical Properties of Irrigation Water*, on page 50), use alternative water sources on the most sensitive plants (e.g., herbaceous material and young woody material). Many plants can tolerate a higher EC if they are watered regularly and leached periodically.

TABLE 3–16. Acceptable Ranges for Chemical Properties of Irrigation Water

These ranges are a general guideline. Ornamental crops vary greatly in their sensitivity to soluble salts and the chemical properties of water.

Chemical Property	Acceptable Range for Most Container-Grown Woody Crops	Acceptable Range for Most Container-Grown Herbaceous Perennials/Greenhouse Crops
pH	5.0–7.0	5.0–7.0
EC (soluble salts)	< 1.75 mS/cm	< 1.0 mS/cm
Calcium carbonates ($CaCO_3$)	< 150 ppm	< 120 ppm
Bicarbonates (HCO_3)	< 150–200 ppm (lower if not being leached with rainfall)	< 100–150 ppm (lower if not being leached with rainfall)
Sodium (Na)	< 70 ppm	< 60 ppm
Chloride (Cl)	< 140 ppm	< 100 ppm
Sulphur (S)	< 70 ppm	< 70 ppm
Sulphates (SO_4)	< 200 ppm	< 200 ppm
Iron (Fe)		< 5 ppm
Boron (B)	< 0.8 ppm	< 0.5 ppm

Water Testing

Along with media and leachate analysis, it is useful to test irrigation water throughout the growing season. Water quality is usually best in the spring, when water volumes are at their highest. Soluble salts are more dilute in spring, giving lower EC values. Bicarbonate levels are also lower in spring. For these reasons, test irrigation water quality in the spring and compare it with subsequent summer and early fall water tests.

Iron levels can be a problem as iron is easily oxidized and forms precipitates that can block irrigation lines or cause uneven spray patterns. Water samples should be tested for a number of chemical attributes (see Table 3–16 above). In OMAFRA Publication 370, *Production Recommendations for Greenhouse Floriculture*, see Table 3-8, *Maximum Desirable Concentrations of Specific Ions in Raw Water Used for Irrigation Purposes in a Greenhouse Using Soilless Substrates.*

Collect samples of irrigation water below the water surface, around the level where the intake line sits. Try to collect water samples when the bottom sediment hasn't recently been disturbed. Collect approximately 500 mL and refrigerate the sample until it can be submitted to the lab.

When lab results indicate certain chemical properties appear beyond the acceptable range, options may include:

- finding an alternative source of irrigation water where chemical properties fall within the acceptable ranges
- finding an alternative source of irrigation water for plants that are most sensitive or have the smallest container volume
- leaching excess solutes from container media through supplemental irrigation with the same water source
- treating the irrigation water to remove salts, using reverse osmosis, for example — an effective but costly solution

4. Insect and Disease Management

Insects, mites, fungi, bacteria, nematodes and viruses are all examples of pests found on plants. In nature, most pests populations are kept "in check" by predators, pathogens, competing organisms or by the natural resistance of a healthy host plant. When other factors such as stress enter the system, pests may become economically damaging.

In production systems, pests have an even greater chance of becoming damaging. Crops are often produced in a monoculture system, allowing pests to move more easily from host to host. As well, some production practices can be quite stressful. For example, container-grown plants have high root-zone temperatures in the summer that can result in root mortality. A reduction in roots will decrease plant health and resistance to pest invasion. Successful growers look for early signs of plant stress and manage that stress to help prevent pest problems.

Integrated Pest Management

Integrated pest management (IPM) is a decision-making process that integrates all available tools to reduce pest populations to an acceptable level in a cost-effective, environmentally rational manner. These tools include monitoring, cultural control, physical control, biological control and chemical control. Nursery growers are adopting a more integrated approach to pest management that allows them to decrease their use of chemical pesticides by making more informed decisions. Landscape professionals and arborists in Ontario must operate under the *Pesticides Act* as amended by the *Cosmetic Pesticides Ban Act*, 2008. The requirements are detailed in Ontario Regulation 63/09.

When making decisions about pest management, one must determine the level of a pest population that can be tolerated. These levels (called *action thresholds*) depend on many factors. Because the diversity of ornamental plants and plant pests is so great, data for specific pest action thresholds is often unavailable. By keeping good records, growers and landscape maintenance professionals can develop their own action thresholds. Action thresholds may be measured by the number of pests present, the percentage of plant parts showing symptoms or the level of pest injury that can be sustained before the economic loss from that injury is equal to the cost of controlling the pests (the *economic injury level*). Most healthy ornamental plants can tolerate moderate levels of pests, but landscape clients and retail garden centre customers may have lower tolerances.

Monitoring

Monitoring is the most important aspect of IPM. Monitoring data provides the basis for making informed decisions about pest management practices. Monitoring programs consist of regular physical examinations of all production areas during the growing season, including winter propagation. Most monitoring activities for pests are carried out on a weekly basis.

Early detection is the key to preventing pests from reaching levels of economic injury and minimizing the use of pesticides.

Crop Scouts

Crop scouts should dedicate their working hours to monitoring plant health and reporting their observations to help direct the pest management program. Crop scouts should:

- sample plants regularly from each production block and look closely under branches, in branch crotches and on leaf undersides for any unusual symptoms
- examine the crown and root systems regularly to monitor for diseases, insects and physiological problems
- see Table 4–1, *Host Symptoms and Possible Causes of Insect Injury*, on page 61 and Table 4–2, *Symptoms and Possible Causes of Insect Injury (by Visible Insect Matter)*, on page 62

Crop scouts need a basic understanding of crop health. This includes some background in crop production, plant pathology, entomology and weed science. Since a wide array of woody and herbaceous ornamentals are grown in Ontario, blocks of plants should be clearly labelled (including cultivar names and planting date) for reference. In the case of landscape properties, a basic map with plant names is an excellent reference for monitoring. Correctly identifying the host is often critical to correctly identify the pest.

With a wide array of crop species comes an extensive group of organisms (insects, mites and micro-organisms) that may be encountered during crop production. Not all these organisms are plant pests; many are incidentals and just happen to be there or are feeding on other non-plant organisms. To help identify pests, the crop scout should have diagnostic references that outline identifying characteristics, host lists, biology and life cycle of the plant pests typically encountered in Ontario. This information can be used not only to identify the pest but also to target where in its life cycle to use various control methods. A hand lens (e.g., 10x to 20x) is a necessary tool for observing a pest's identifying characteristics. Diagnostic references may include ornamental woody and herbaceous reference books, government and university publications and websites. For more information on diagnostic references, see the OMAFRA Nursery-Landscape webpage at www.ontario.ca/crops. The Pest Diagnostic Clinic offers pest identification services (see Appendix D, *Diagnostic Service*, on page 198).

Growing Degree Days (GDD) and Phenology Models

In the past, calendar dates were used to determine when to apply pesticides. This often led to unnecessary pesticide applications and applications that did not coincide with the susceptible developmental stage of the pest. Today, pest management techniques include temperature, weather data and plant-pest phenology (developmental) models. The underlying principle is basic: Plants and insects need a certain amount of heat to pass through the various stages of development. The temperature data is often expressed as Growing Degree Days (GDD). To calculate these, collect maximum and minimum temperatures over a 24-hour period. Then use the following formula below to calculate GDDs with various base temperatures (i.e., 10°C, 50°F). Add daily GDDs together to get a running total of GDD accumulations in your area. Only positive calculated values are accumulated.

Growing degree days formula

$$\frac{\text{Daily Maximum Temperature} + \text{Daily Minimum Temperature}}{2} - \text{Base Temperature}^{*} = \text{Growing Degree Days}$$

** Base temperature is a constant.*

Sample calculation (at base 10°C):

$$\frac{17^{\circ}\text{C} + 5^{\circ}\text{C}}{2} - 10^{\circ}\text{C} = 1\ \text{GDD}\ (10^{\circ}\text{C})$$

Growing Degree Days are meant to enhance the monitoring program, not replace it.

Growers and landscapers use GDD models to help predict the emergence of pests based on temperature data they have collected themselves or obtained from the local weather office. The GDD pest models can be used to fine-tune the monitoring program and anticipate pests early. Over time, recorded temperature data for plants and plant pests have revealed that certain plants and insects pass through developmental stages at the same time. For example,

when the *Magnolia x soulagiana* flowers are in the pink bud stage, the overwintering spruce gall adelgid nymphs are starting to feed and are susceptible to applications of insecticides. The fruiting and flowering characteristics of certain common ornamentals in the landscape have been linked to the developmental stages of plant pests. These plants are referred to as "plant phenology indicators" (see Table 4–3, *Common Phenology Plant Indicators for Ontario*, on page 63).

Where plant health monitoring will be carried out in many locations (as in the case of landscape maintenance), use plant phenology indicators to direct the monitoring program. The combined collection of GDD data and plant phenology indicators can give a clearer picture of the timing of pest emergence and opportunities for control. For more information, see tables 4-4 to 4-17, starting on page 64.

For more information on timing and control methods for ornamental pests in Ontario, see the OMAFRA Nursery and Landscape Report on the OMAFRA website (www.ontario.ca/crops).

Monitoring Tools

Many tools exist to help crop scouts monitor plant pests. Although they are collectively called "traps," many of these tools are not effective at managing pest populations. Instead, they are useful as a means of collecting data about insect emergence and populations.

- Most *baited traps* are pheromone (mating) lures or other lures (e.g., floral lures) to attract insects. Place at least two traps per monitoring area about 1–2 weeks before adults are expected to emerge. Place traps on the windward side of the monitoring area. Try to use the same type of pheromone and brand of trap.
- *Refuge traps* provide places for insects to hide (e.g., burlap traps for black vine weevil adults and gypsy moth larvae).
- *Sticky traps* (yellow, blue, etc.) catch adult flying insects (e.g., aphids, whiteflies, leafminer adults, thrips, leafhoppers).
- *Tape* wrapped around stems and small branches (sticky side out) will capture scale insect crawlers for monitoring purposes.
- *Tapping trays* are useful for monitoring pests such as mites, plant bugs and caterpillar droppings. They consist of a white surface fixed on a frame (or a sheet of white paper on a clipboard) that is held beneath a branch. When the branch is tapped, pests drop onto the white surface, where they are visible.
- *Pitfall traps* can be used to monitor flightless pests (such as root weevil adults and slugs). They are a cup-shaped trays placed in the ground so that the top of the tray is level with the surface of the ground.

Monitoring Data Records

Record observations in an organized and accessible system (e.g., a computer data file). Remember, this monitoring data is very useful in fine-tuning action thresholds and pest management strategies in future years. Organize monitoring data under headings such as:

- date (month/day/year)
- location (e.g., farm X, block C)
- host (including cultivar or variety, stage of development)
- pest or symptoms (including pest population, pest stage of development, percentage of plants or plant parts showing symptoms)
- GDD and/or plant phenology indicators
- action taken (e.g., pesticides, rate, area treated)

A sample Pest Monitoring Record Sheet can be found in Appendix F, *Pest Monitoring Record Sheet*, on page 204.

Indicator Plants

Indicator plants are ornamentals that seem to attract specific pests first. For example, *Caragana* and *Acer* serve as indicator plants for leafhoppers. Examine these plants at the beginning of each monitoring cycle. By observing indicator plants, it is possible to detect pest problems before they reach economically damaging levels and affect the rest of the crop.

Cultural Control

Cultural control activities are practical plant care practices. Remove infested plant material or pests (including weeds) from production areas and landscapes and destroy them. Use supplemental irrigation if natural precipitation is inadequate. Avoid irrigating late in the day, as leaf wetness periods that extend into the night may increase disease problems. Where disease is a problem, try to irrigate less often, but with adequate volumes to wet the soil and encourage deeper rooting. Grow plant cultivars that are tolerant of diseases and insects. For example, *Betula nigra* and its cultivars are more tolerant of bronze birch borer than *Betula pendula.* Steam-pasteurize propagation media before reusing it. It is very difficult to sterilize pots and inserts. Always start the propagation phase of disease-susceptible species with new pots or trays. This will help minimize the risk of transferring disease (e.g., Fusarium) from organic residue on used pots. Select only healthy plants for cuttings and budwood to avoid introducing problems into the production system.

Physical or Mechanical Control

Physical means, such as mechanical cultivating field soils to injure weeds, can also reduce pest populations by exposing soil-dwelling insects to natural predators. Apply sticky bands on the trunks of landscape trees to trap or exclude crawling insects and reduce egg-laying (e.g., adult female gypsy moths). Yellow sticky tape can also provide supplementary control of flying insect pests in propagation greenhouses. When new plant material is received by a nursery, hold it in a quarantine area (away from production areas) and monitor it for any pests or diseases.

Biological Control

There are many natural predators and parasites that keep pest populations in check. For example, predatory mites feed on many species of pest mites. Ladybird beetles (larvae and adults) and lacewings (larvae) are common predators outdoors. They feed on soft-bodied insects such as aphids, mites and scale nymphs. Ichneumonid wasps are also common parasites. The adult females lay their eggs inside soft-bodied insects such as aphids. The wasp eggs hatch and feed on the contents of their aphid host, eventually killing the host. Many broad-spectrum insecticides used to reduce pest populations also reduce populations of natural predators. When monitoring for pest populations, look for natural predators and parasites, as they are also an important aspect of pest control that can reduce the need for chemical pesticides in some situations. When choosing a pesticide, consider those that have the least impact on natural predators and parasites.

Many biological-control organisms are commercially available in Ontario. Most biological-control products are available for the control of insects and mites and are most successful in closed systems such as greenhouses. Some predatory insects can be effective in the field, especially where a continuous supply of pollen and nectar are available throughout the growing season. Many predators need the energy they obtain from flower pollen and nectar in order to reproduce within that area. Predatory mites may also reduce pest mite populations in the field over the long term. Recent studies with entomopathogenic nematodes (*Heterohabditis megidis*) have shown excellent control of root weevils in container production and about a 50% reduction of root weevil populations in the field. For more information on biological control products, see OMAFRA Publication 370, *Production Recommendations for Greenhouse Floriculture.*

Chemical Control

When all other methods of management fail or when pest populations are threatening the economic value of the plants, pesticides may be the most effective solution. The pesticide program is an important part of IPM. Make pesticide applications in accordance with monitoring observations. Choose the most appropriate product, keeping in mind the pest and host plants it will be used on. Apply the product to coincide with the susceptible stage of the pest (according to monitoring observations). Before using a pesticide, read the product's label and understand its relative toxicity, mode of action, persistence and proper and safe application. For more information on pesticide safety, see Chapters 1 and 2.

Chemical pest control products are an important tool in crop production, but they must be used carefully to minimize their impact on the environment and prevent the development of pesticide resistance. While a particular level of pesticide is lethal to most individuals within a population, some individuals may survive to pass on their genes. Over time, this can lead to widespread resistance within the population. Pests become resistant to chemical pesticides when the products are used incorrectly or too often. Make note of the chemical family of each pesticide and ensure that chemical families are being rotated during the application period for each target pest. (See Table 4–20, *Chemical Families*, on page 89, and Table 4–21, *Insecticides and Fungicides Used to Protect Ornamentals (by Product Name)*, on page 90.)

Best Management Practices

Growers and landscape professionals can have a major influence on plant health by considering environment (media, soil, irrigation, temperature, hardiness zone, light, spacing, planting location, etc.) and nutrients (type, rate, delivery). Slight changes in environment and nutrient availability can have dramatic effects on plant health. In the landscape, a significant portion of pest problems are due to inappropriate site conditions. Before installing landscape material, consider the basic needs of the plants (hardiness zone, soil pH, sunlight requirements, soil type, water, etc.). By following practices that produce and maintain healthy plants, many plant pests can be prevented from causing economic damage.

Implementing a biosecurity protocol will help to minimize the risk of introducing and transmitting biological hazards (e.g., pathogens, parasites or pests) to, within and between production facilities. Ensure the protocol is followed by all employees and visitors. A biosecurity protocol outlines the best management practices for effective sanitation. Some examples include ensuring that all visiting vehicles are parked in designated areas and that all visitors check in at the office. This policy will ensure that all visitors are aware of the facility's biosecurity protocol. Foot baths and hand/boot washing stations placed at key points throughout the facility can help reduce the introduction and spread of pests.

Best Management Practices (BMPs) are an integral part of good crop management. Every grower should have guidelines to produce and maintain plants in a responsible manner. Many BMPs focus on effective water and fertilizer use (both for healthy plants and a healthy environment), the recycling of plastics and the responsible use of pesticides. Monitor irrigation water quality and analyze growing media/leachate to catch problems early.

Sample irrigation water from each water source in the spring, summer and fall. It is good to test at least three times per year, since water levels change throughout the seasons, influencing the concentration of harmful salts. Have the samples tested for pH, EC, bicarbonates, sodium, chloride, sulphur, sulphates and boron at an accredited lab. See Table 3–1, *OMAFRA-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories*, on page 25, for a list of accredited labs and Table 3–16, *Acceptable Ranges for Chemical Properties of Irrigation Water*, on page 50, for a comparative table of chemical properties of good-quality irrigation water.

In the nursery, sample container leachate every 2 weeks using the Pour-Thru Procedure (or Virginia Tech Extraction Method) for nursery crops (www.ces.ncsu.edu/depts/hort/hil/hil-401.html) as follows:

1. Allow 30–60 minutes to let pots drain after the last irrigation.
2. Place saucers underneath the pots or place the pots inside other pots with a plastic bag in between.
3. Pour enough distilled water over the pot surface to collect about 50 mL of leachate from the pot bottom. Take leachate samples from at least five pots per block (or irrigation zone) to get a good representation of the block.
4. Submit the samples to an accredited lab.

Compare EC and pH over time and monitor fertilizer salts (e.g., N, P, K) in the soil solution. Over time, develop a database that correlates salt levels and pH with healthy plant growth. This approach allows spikes in salt levels to be detected early. When they are, using remedial watering to leach out salts will help avoid root injury before

plant damage results. Analysis will also reveal any drop in fertilizer salt levels, when supplemental applications may be warranted. In the field or landscape, sample soils where new plantings are planned or where plant growth seems to be below optimum. For directions on testing container media see How to Sample and Test Container Media, page 45, and Table 3–15, *Media Nutrient Levels for Most Container Crops,* on page 47. For directions on testing field soil see How to Sample Field Soil, page 26, as well as Table 3–6, *Phosphorus Requirements for New and Established Field Nursery Stock* and Table 3–7, *Potassium Requirements for New and Established Field Nursery Stock* (page 32).

For more information, see:

- ***Best Management Practices: Integrated Pest Management*, Order No. BMP09**

Insects and Mites Affecting Trees and Shrubs

Insects and mites are broadly classified according to their feeding habits and the associated damage they cause to woody plants. Classifications include defoliators, sucking insects, borers, gall makers and soil pests.

Some damage is distinctive, allowing identification of the insect that caused it without even seeing the pest at work (see Table 4–1, *Host Symptoms and Possible Causes of Insect Injury,* on page 61). A hand lens (e.g., 10x–20x) can be helpful to see some tiny pests such as mites. Other pests develop within the plant tissues, concealed from view.

Defoliators

Defoliating insects eat solid foliage tissue. They may feed singly or in dense colonies and have diverse feeding habits. For example, some defoliators consume entire leaves, while others eat only interveinal tissue. Some skeletonize the leaf surface, leaving only the leaf veins behind, while others mine between the leaf surfaces.

Some defoliators are visible on leaves, while others hide within a web, folded leaf or portable shelter. However, all defoliators damage plants by reducing the leaf area. This interferes with photosynthesis, depriving the plant of food. It also interferes with the transportation and translocation of food within the plant. Some common types of defoliators are listed below. A Compendium of Pests And Diseases appears on page 94.

Caterpillars

Caterpillars are moth and butterfly larvae. They may feed in colonies or individually. Caterpillars have three pairs of true legs on the abdomen, close to the head. They also have up to five pairs of fleshy "pro-legs" located further back along the abdomen. Loopers or "inch worms" are examples of caterpillars that have two to three pairs of fleshy pro-legs.

Leaf-Eating Beetles

Many beetles feed on leaves both as adults and as larvae. Beetles can completely devour, skeletonize (leaving only leaf veins behind) or mine the leaves.

Leafminers and Casebearers

Leafminer and casebearer larvae develop within leaf tissues or in a protective case of leaf fragments that they carry to their feeding site. While the pests are often concealed, their characteristic tunnels make leafminer infestations easy to identify. The tunnels may be straight, serpentine or irregular.

Sawflies

Sawflies feed in colonies and quickly strip foliage from their host plants. In Southern Ontario this usually occurs during June and July. The adults have two pairs of wings and often resemble small bees, ranging in colour from amber to black. The larvae of most species look similar to caterpillars, with three pairs of true legs on the abdomen (close to the head). They usually have six or more pairs of fleshy "pro-legs" located further back along the abdomen.

Sucking Insects

Sucking insects include aphids, lacebugs, leafhoppers, mealybugs, mites, scales, spittlebugs and thrips. This group of pests weakens trees and shrubs by sucking the sap. Some also inject secretions that injure or kill plant cells. Most species, though small and inconspicuous, are very troublesome pests.

Because their foliage is not chewed or torn, infested plants may suffer severe injury before symptoms appear. Signs of damage include mottling and fading leaf colour, curling and twisting leaves, wilting foliage and tender shoots, hardening flower buds and malformed flowers or leaves.

Some common types of sucking insects are listed below. As well, see *A Compendium of Pests and Diseases with Recommended Management Practices*, on page 94.

Aphids

Aphids (plant lice) are small, soft-bodied, pear-shaped insects that vary from green to shades of red, brown or black. Some aphids feed on the leaves, while others feed on the roots and are often associated with a woolly mass. Leaf-feeding aphids commonly cluster on new growth or on the underside of leaves. The light-coloured cast skins of nymphs often remain attached to the lower surface of a leaf, similar to leafhoppers.

Aphids secrete a sweet sticky substance called "honeydew" that attracts ants, flies and wasps. Honeydew can be a nuisance when it coats objects beneath infested plants. A black sooty mould may grow on the honeydew, making the plants unsightly. This fungus does not infect the plant host.

Leafhoppers

Leafhoppers are small, wedge-shaped, active insects that run, hop or fly when disturbed. Leafhoppers are usually greenish or yellow in colour, although some are striped. They commonly injure woody hosts such as apple, caragana, elm, honeylocust, hoptree, maple and rose.

Leafhoppers feed on the undersides of leaves, causing stippling or bleaching and, often, blackened leaf margins. Small yellowish dots appear on the upper surface of the affected leaves. The light-coloured cast skins of nymphs often remain attached to the lower surface of a leaf (similar to aphids), providing a critical clue to help identify the pest problem. Be cautious: it's easy to confuse leafhopper injury with that caused by two-spotted spider mite.

Mites

Mites are very tiny animals related to spiders and ticks. They are not true insects. Sometimes called "spider mites," they produce webbing between plant needles or leaves. This keeps the mites from becoming dislodged and protects them from their natural enemies.

Mites reproduce rapidly during hot, dry weather and may produce several generations a year. They attack evergreens and deciduous trees, causing speckling, bleaching or bronzing of foliage. Tiny spherical eggs or broken eggshells appear as specks or spots. In severe mite infestations, foliage may drop prematurely.

Serious mite damage happens quickly, so it is important to identify mite infestations early in the season. Most mites are not visible with the naked eye. To identify a mite infestation, use a 10x–20x hand lens. Alternatively, hold a sheet of white paper under a branch and tap the branch sharply. Some mites will drop onto the paper, where they appear as tiny specks about the size of a pencil dot as they crawl about.

Mite species commonly associated with trees are:

- European red mite (*Panonychus ulmi*) on fruit trees
- oak red mite (*Oligonychus bicolor*) on oaks
- honeylocust spider mite (*Eotetranychus multidigituli*) on honeylocust
- maple spider mite *(Oligonychus aceris)* on silver-red maple hybrids
- spruce spider mite (*Oligonychus ununguis*) on spruce, hemlock, arborvitae and juniper
- two-spotted spider mite (*Tetranychus urticae*) on elm, linden, rose and ornamental fruit trees
- rust mites (various) on elm, honeylocust, maple, oak and privet

Thrips

Thrips are very tiny, slender-bodied insects that affect the leaves and flowers of several woody and herbaceous plants. They have piercing, sucking mouthparts and often feed from the inside of a leaf, leaf bud or flower bud. Thrips damage is often not apparent until infested buds open and reveal mottled and distorted growth.

Plant Bugs

This group of insects removes plant sap using piercing, sucking mouthparts. Both adults and nymphs cause damage, often injuring young, developing shoots and leaves. Symptoms of damage include stippled leaves, deformed leaves and stunted shoots.

Scale Insects

Scale insects are tiny and inactive for most of their lives. They often blend in with the host plant's colour and feed from the undersides of twigs and leaves, making them difficult to find. For ease of identification, scales are divided into three groups called armoured scales, soft or unarmoured scales and mealybugs.

Armoured Scales

Armoured scales are common on trees and shrubs. The scales vary in length or diameter from 2–3 mm and secrete a hard, waxy covering over their bodies. Armoured scales may be circular, oblong or pear-shaped. Examples include oystershell scale and euonymus scale.

Soft Scales

Soft scales include Fletcher scale and magnolia scale. They are either bare or enclosed in waxy or cottony secretions.

Mealybugs

Mealybugs are soft-bodied insects that are usually covered with a powdery, cottony-wax material and produce honeydew. They range from about 5–8 mm long when full grown. Unlike other scale insects, mealybugs are mobile throughout their entire life cycle. The most common mealybug seen on outdoor ornamentals is the taxus mealybug.

Borers

Borers are beetle and moth larvae that tunnel into the buds, shoots, bark or wood of trees and shrubs. Some species attack healthy trees, but most attack trees and shrubs already weakened from another stress. The larval stage feeds from within the tree (on the bark, cambium or inner wood). Emerald ash borer (*Agrilus plannipennis*) and Asian long-horned beetle (*Anoplophora glabripennis*) are two of the newest borers found in Ontario. For more information see *A Compendium of Pests and Diseases with Recommended Management Practices*, on page 94. Emerald ash borer and Asian long-horned beetle are quarantine pests, and movement of the insects and the infested plants or plant parts is regulated to help prevent further spread into uninfested areas. For more information, contact the closest office of the Canadian Food Inspection Agency (www.inspection.gc.ca).

It is important to prevent borer injury, as infested plants may be damaged beyond repair before the pest makes itself known. Signs of damage include dying twigs and branches (especially true for bronze birch borer); dark, discoloured or dead areas under the bark; and chewed matter or sawdust under the bark. Sap and sawdust-like borings may cling to bark and litter the ground.

Borers also provide an entrance for disease-causing fungi. They can weaken trees, making wind damage likely, and may eventually girdle and kill the tree. The most serious borers are those whose larvae feed in the cambium, the green, sap-conducting and generative tissue located just under the bark.

Gall Makers

Galls are abnormal vegetative growths produced by a plant in response to insect irritations or substances that mimic plant growth hormones. Causes include feeding, stinging, egg-laying or toxin injection. This reaction generally benefits the pest by creating a protected feeding site.

Aphids, mites, midges, gall wasps and some beetles and moth larvae can all produce galls. Galls vary greatly in size, colour and complexity, but each insect species produces a characteristic gall

formation. Oaks and hickories are the favourite hosts for several hundred different gall insects.

Galls may form anywhere on a tree. They impair the appearance and shape of trees and may kill leaves and branches, although they rarely kill the tree.

Soil Pests

Pests below the soil line can seriously damage plants before making themselves known. It can be difficult to determine the extent of the pest problem or the effectiveness of treatment. Monitoring programs should include examination of crowns and roots below the soil, especially where symptoms of stress are evident. Some common types of soil pests are listed below.

Japanese Beetles

Japanese beetles (*Popillia japonica*) are a quarantine pest. This means that the movement of Japanese beetles and infested plants or soil are regulated to help prevent further spread into uninfested areas. While they are not a major cause of damage to nursery crops in Ontario, it is important to control infestations and prevent new ones. Established populations exist in several counties of Ontario. Contact your local CFIA office (see Appendix C, *Other Contacts*, on page 196) for a current list or refer to the CFIA website at www.inspection.gc.ca.

Japanese beetle larvae are C-shaped, milky-white grubs about 25 mm long. They have brown heads and three pairs of legs. A V-shaped arrangement of spines on the last abdominal segment (raster) distinguishes them from other grubs. The larvae feed on the roots of turf and nursery stock.

Managing Japanese Beetles in Nurseries

Refer to the Canadian Food Insepction Agency Directive D-96-15, Phytosanitary requirements to prevent the spread of Japanese beetle, *Popillia japonica*, in Canada and the United States (www.inspection.gc.ca). Use the following strategies to reduce injury and grub populations:

- Treat container-grown stock with CFIA-approved insecticides. See CFIA guidelines regarding the treatment of Japanese beetle to allow for shipping of nursery stock (www.inspection.gc.ca).
- Watch for emerging adult beetles. Check the OMAFRA Nursery-Landscape Report to see if adult beetles have been reported. The report is available online and also by phone. Phone numbers and crop updates can be found on the crops page of the OMAFRA website (www.ontario.ca/crops).
- Monitor for adult Japanese beetles using traps beginning around the time *Catalpa speciosa* is beginning to bloom (around mid-June in southern Ontario). Note that traps are used for monitoring, not for control. To avoid attracting beetles to your nursery, place traps in nearby pastures, vacant fields or fence rows. Research shows that if fewer than 4,000 beetles are trapped at peak flight, a larval population likely has not been established (especially in clean cultivated soils).
- Scout fence rows and hedgerows once adult beetles emerge. Look for beetles feeding on leaves of indicator plants (e.g., grapevines, roses), especially in early morning or late afternoon. Skeletonized leaves are a sign of Japanese beetle injury.
- Remove wild grape and other weedy host plants from the area. Adult beetles feed on different host plants than their larvae. Discourage adult beetles from feeding in the area by removing food sources. For a list of common host plants, see OMAFRA Factsheet *Japanese Beetle in Nurseries and Turf, Order No.* 92-108.
- Control beetles in fence rows and hedges first. If beetles are observed feeding, apply insecticides before 7 A.M., when beetles are sluggish and slow.
- Discourage egg-laying in the nursery by eliminating suitable egg-laying sites near desirable host plants. Japanese beetles lay eggs in turf areas such as pastures and grassy, weedy areas. Almost all grasses support larval populations, while alsike clover, crown vetch, white Dutch clover and Canadian mammoth clover do not.
- Keep soil that will be dug with the plant at harvest free from vegetation. Provide an extra-wide clean, cultivated area at the base of trees.
- Cultivating to a depth of 7.5 cm may destroy 25%–30% of the larvae. Cultivating is most effective in early fall and late spring.

- Low, wet, poorly drained areas and irrigated fields are preferred egg-laying sites during droughts.
- Containers with soilless media are not preferred egg-laying sites. Avoid the use of soils in container media in infested areas.
- Maintain a good weed control program in the field and in the container yard.

Other White Grubs

In addition to Japanese beetle larvae, the larvae of European chafers (*Rhizotrogus majalis*) and June beetles (*Phyllophaga* sp.) make up the group of insects called "white grubs." White grubs larvae move into a distinctive "C" shape when uncovered in the soil. They have a brown head capsule, three pairs of legs and an abdomen with a uniform width. Larvae of white grubs are very similar. To identify the species, closely examine the tiny spines on the raster (the last segment of the body). June beetle larvae have two parallel rows of stout spines on the raster and a Y-shaped anal slit. Japanese beetle larvae have two short rows of stout spines in a distinct "V" pattern on the raster and a crescent-shaped anal opening. European chafer larvae have 2 nearly parallel rows of spines on the raster that diverge slightly at the hind end and a Y-shaped anal slit. Mature June beetle larvae are the largest (up to 4 cm long), followed by European chafer (1.5 cm) and Japanese beetle (1.25 cm). The adult beetles fly and may cause feeding damage on the foliage of outdoor ornamentals.

Although white grub larvae traditionally attack turf, they have been expanding their host range. In the last several years, white grub larvae have been found feeding on the roots and crowns of woody nursery stock in the field. There have also been several cases of white grubs feeding on vegetable crops and cash crops in southwestern Ontario. Monitor for grub populations in late summer. Registered insecticides for preventive purposes are most effective when used at the beginning of adult flight periods since they will be present in the soil when the eggs are hatching. Registered insecticides (including nematodes) for curative or rescue purposes are most effective when applied by late summer when the grubs are still small enough to be susceptible and are feeding near the surface. Some indicator species (hosts) for white grubs include Japanese tree lilac, fir and spruce.

Root Weevils

Root weevils are small (up to 1 cm long), white larvae that feed on the crown and roots from under the soil, which often severely damages or kills the plant. Root weevils have a brown head capsule and no legs and are fatter in the centre of their abdomen than at their ends. The absence of legs and uneven thickness distinguishes them from white grub larvae. The two most common root weevils in Ontario are black vine weevil (*Otiorhynchus sulcatus*) and strawberry root weevil (*Otiorhynchus ovatus*). Strawberry root weevils feed on crops such as white cedar and Colorado spruce, while black vine weevils have a much larger ornamental host range. Adult root weevils are flightless, are all female and resemble a beetle except that they have a long snout. These adults crawl around and feed during the night by cutting notches into leaves. The leaf notches rarely lead to serious damage but are an indication that a weevil population is present. Inspect crowns and roots for weevil larvae and feeding damage any time from September through May. This is the period when weevil larvae are most likely to be present.

Weevil larvae are difficult to control with chemicals since they can be found associated with the root system and are protected by the soil. Recent studies have shown that entomopathogenic nematodes (e.g., *Heterohabditis bacteriophora*) control root weevils extremely well in container production but reduce root weevil populations in the field (where irrigation seems to be the limiting factor) by only 50%. Adult weevil populations can be reduced by using registered contact insecticides applied to the foliage during the early evening. Indicator species for root weevils include *Taxus, Rhodondendron, Euonymus, Thuja, Heuchera* and *Sedum.*

Nematodes

Nematodes are tiny, thread-like roundworms that feed and multiply in or on a wide range of plant roots. Necrosis (dead tissue) or localized swellings in roots may indicate possible feeding sites. Nematodes may also spread soil-borne viruses and permit the

development of secondary bacterial and fungal infections. Nematodes are often more prevalent in wet, poorly drained soils (especially during the growing season following a rainy year). They are more common in low-lying areas of the field. Although populations will rise dramatically during a wet growing season, symptoms of the infestation often don't show up until the following year.

Treat potential nematode problem areas before planting, using registered products such as Basamid and Vapam. Use these materials according to the manufacturer's instructions. Manage nematode diseases by rotating crops, sterilizing the soil and disinfecting dormant planting material. For directions on sampling for nematodes, see Appendix D, *Diagnostic Service*, on page 198.

Consult the OMAFRA website at ontario.ca/omafra for detailed information about nematode problems, preplant soil fumigation and the fumigation of established crops. See *Soil Fumigants*, on page 175, for more information.

Use Table 4–1 to identify insect injuries to nursery and landscape plants from plant damage.

TABLE 4–1. Host Symptoms and Possible Causes of Insect Injury

Category	Symptom	Possible Causes
Chewed leaves and/or chewed flowers	◆ pieces of leaf or flower missing ◆ entire leaves or flowers missing	◆ caterpillars (moth larvae, butterfly larvae) ◆ beetle larvae or adult beetles ◆ sawfly larvae ◆ grasshoppers ◆ snails ◆ slugs
Discoloured leaves	◆ bleached leaves ◆ bronzed leaves ◆ silvered leaves ◆ stippled leaves ◆ streaked leaves	◆ lace bugs ◆ plant bugs ◆ spider mites ◆ leafhoppers ◆ aphids ◆ psyllids ◆ thrips
Plant part distortion	◆ mined leaves ◆ skeletonized leaves ◆ curled/cupped leaves ◆ galls on leaves, stems, flowers, twigs ◆ twisted growing points	◆ beetle larvae ◆ caterpillars ◆ sawflies ◆ aphids ◆ gall wasps ◆ gall flies ◆ psyllids ◆ eriophyid mites
Plant dieback	◆ dying leaves, twigs, branches ◆ dying whole plant ◆ holes and frass ◆ wilting	◆ twig pruners ◆ root feeding beetle larvae ◆ boring insects ◆ scales ◆ adelgids

Soybean Cyst Nematode

Soybean cyst nematode, *Heterodera glycines*, is a concern in southwestern Ontario, especially in Kent, Perth, Elgin, Essex and Prescott and Russell counties. While most field-grown nursery stock does not host this pest, practising good soil management can help reduce its spread.

- Do not grow nursery stock on fields recently used to produce soybeans.
- Do not use equipment in nursery fields that was used to cultivate soybean fields. Attached soil can spread the nematode cysts.
- Prevent soil erosion.
- Many weeds act as host plants to soybean cyst nematode. Good weed control will reduce populations.
- Nematicides are ineffective against this pest.

Use Table 4–2 to identify insect injuries to nursery and landscape plants from visible insect matter.

TABLE 4–2. Symptoms and Possible Causes of Insect Injury (by Visible Insect Matter)

Symptom	Possible Causes
Dark fecal spots	• aphids • soft scales • leafhoppers • mealy bugs • psyllids • whiteflies
Honeydew Sooty mould	• lacebugs • greenhouse thrips • some plant bugs • sawfly adults
Silken mats Spittle Tents Webs	• leaf rollers • leaftiers • spittlebugs • tent caterpillars • webworms
Sap flow	• larvae of certain kinds of moths and beetles
Pitch tubes	• bark beetles
Cast skins	• aphids • cicadas • clearwing moth larvae • lacebugs • leafhoppers
Pitch mass	• larvae of certain kinds of moths and beetles
Flocculence (cottony waxy material)	• adelgids • aphids • certain scales • mealybugs • psyllids
Slime	• slugs • snails

Phenology and Growing Degree Day Tables for Monitoring

The following tables describe some of the more common insect and mite pests present in Ontario nurseries and landscapes. Table 4–3, *Common Phenology Plant Indicators for Ontario*, on page 63 is a list of phenology plants whose fruiting or flowering indicate the emergence and development of certain insect pests that correlate with Growing Degree Day (GDD) summary models. For more detailed information regarding GDDs, see *Monitoring*, on page 64. Tables 4–4 to 4–17 outline phenology plant characteristics, GDD summaries and pest descriptions to help plan monitoring schedules in the outdoor nursery and landscape. The presence of a "V" in the "Stage" column indicates this pest is vulnerable to chemical control, which may include dormant oil.

Obtain the daily maximum and minimum temperatures needed to calculate GDDs from weather stations such as Environment Canada or Weather Innovations Incorporated or extract them from on-farm weather stations. The OMAFRA Nursery and Landscape Report contains GDD accumulations for some of the regions of Ontario where nursery operations are most concentrated. The OMAFRA Nursery and Landscape Report message is available on the crops page of the OMAFRA website (www.ontario.ca/crops) from April to October.

TABLE 4–3. Common Phenology Plant Indicators for Ontario

Acer platanoides	Norway maple
Acer rubrum	red maple
Acer saccharinum	silver maple
Acer saccharum	sugar maple
Aesculus hippocastanum	horsechestnut
Aesculus parviflora	bottlebrush buckeye
Amelanchier laevis	serviceberry, shadberry
Catalpa speciosa	northern catalpa
Cercis canadensis	redbud
Cirsium arvense	Canada thistle
Cornus alternifolia	pagoda dogwood
Cornus mas	cornelian cherry dogwood
Crataegus phaenopyrum	Washington hawthorn
Daucus carota	wild carrot, Queen Anne's lace
Gleditsia triacanthos	honeylocust
Hamamelis vernalis	spring-blooming witchhazel
Hamamelis virginiana	fall-blooming witchhazel
Hydrangea arborescens 'Grandiflora'	hills of snow hydrangea
Hydrangea paniculata 'Grandiflora'	panicle hydrangea
Kolkwitzia amabilis	beautybush
Lonicera korolkowii 'Zabelii'	zabel honeysuckle
Lonicera tatarica	tartarian honeysuckle
Magnolia x soulangiana	saucer magnolia
Philadelphus	mock orange
Pinus mugo	mugo pine
Prunus x cistena	purpleleaf sand cherry
Prunus serotina	wild black cherry
Prunus triloba	flowering almond
Ribes odoratum	golden or flowering currant
Robinia pseudoacacia	black locust
Salix caprea	pussy willow
Sambucus canadensis	American elder, elderberry
Solidago canadensis	Canada goldenrod
Sorbus aucuparia	European mountain ash
Spiraea nipponica 'Snowmound'	snowmound spiraea
Spiraea x vanhouttei	bridal wreath spiraea
Syringa reticulata	Japanese tree lilac
Syringa villosa	late lilac
Syringa vulgaris	common lilac
Ulmus pumila	Siberian elm
Viburnum carlesii	Koreanspice viburnum
Viburnum dentatum	arrowwood viburnum
Viburnum lantana	wayfaring tree viburnum
Viburnum opulus	European cranberrybush viburnum
Weigela florida	old-fashioned weigela
Yucca filamentosa	Adam's needle

TABLE 4–4. Monitoring for Late March/Early April (1–25 GDD[1] Base 10°C)

(V) indicates this pest is vulnerable to chemical control.

Green Leaf Bud Stage	Flower Bud	Starting Bloom	Full Bloom
Gleditsia triacanthos	*Syringa vulgaris*	*Acer rubrum*	*Acer saccharinum*
Syringa vulgaris		*Acer saccharum*	
		Cornus mas	
		Salix caprea	

Plant	Pest	Developmental Stage
Apple, cherry, crabapple, hawthorn	Eastern tent caterpillar	Overwintering egg mass on small twigs
Elm	Elm bark beetle	Adults (V), eggs under bark
Maple	Gall mites and wasps	Adults (V), eggs on new leaves
Pine	European pine shoot moth	Overwintering larvae in buds and tips (V)
	Pine bark aphid	Overwintering nymphs, hatching nymphs (V)
	Pine shoot beetle	Adults (V), eggs under bark
	White pine weevil	Adults (V) in leaf litter, on terminals
Spruce	Cooley and eastern spruce gall adelgid	Overwintering nymphs next to buds becoming active
Various deciduous trees	Gypsy moth	Overwintering egg mass on tree trunks, other wooden objects
Various deciduous trees and shrubs	Scales, adelgids, mealybugs, mites	Inspect plants that looked damaged last year
Various evergreen trees and shrubs	Spruce spider mite	Overwintering eggs (V) on twigs and foliage

[1]GDD = Growing degree days. For more information, see page 52.

TABLE 4–5. Monitoring for Mid-April to Late April (25–55 GDD[1] Base 10°C)
(V) indicates this pest is vulnerable to chemical control.

Green Leaf Bud Stage	Flower Bud	Mid-Bloom	End Bloom	New Leaves
Gleditsia triacanthos	*Acer platanoides*	*Acer rubrum*	*Acer saccharinum*	*Ulmus pumila*
Syringa vulgaris	*Amelchier laevis*	*Cornus mas*		
	Magnolia x soulangiana	*Forsythia* sp.		
		Magnolia stellata		
		Salix caprea		

Plant	Pest	Developmental Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	New larvae (V), tiny tents
Birch	Birch leafminer	Tiny, black sawfly adults around new leaves; use sticky traps to monitor
Elm	Elm bark beetle	Adults (V), eggs under bark
Evergreens	Spruce budworm	Larvae (V)
Maple	Gall mites and wasps	Adults (V), eggs on new leaves
Pine	European pine shoot moth	Overwintering larvae in buds and tips (V)
	Pine bark aphid	Overwintering eggs, hatching nymphs
	Pine shoot beetle	Adults, eggs under bark
	White pine weevil	Adults (V), eggs on terminals
	Zimmerman pine moth	Overwintering larvae
Spruce	Cooley and eastern spruce gall adelgid	Overwintering nymphs next to buds (V)
Various deciduous trees	Gypsy moth	Overwintering egg mass on tree trunks, other wooden objects
Various deciduous trees and shrubs	Scales, adelgids, mealybugs, mites	Inspect plants that looked damaged last year

TABLE 4–5. Monitoring for Mid-April to Late April (25–55 GDD[1] Base 10°C) *Continued*

(V) indicates this pest is vulnerable to chemical control.

Plant	Pest	Developmental Stage
Various nursery stock in field	White grubs	C-shaped grubs in soil around damaged roots
Viburnum	Viburnum leaf beetle	Eggs on twig undersides (visible as rows of brown bumps); prune out
Yew	Fletcher scale	Overwintering nymphs on undersides of twigs and foliage

[1]GDD = Growing degree days. For more information, see page 52.

TABLE 4–6. Monitoring for Late April to mid-May (55–100 GDD[1] Base 10°C)

(V) indicates this pest is vulnerable to chemical control.

Leafing Out	Flower Bud	Early Bloom	Full Bloom
Acer saccharinum	*Aesculus hippocastanum*	*Amelanchier laevis*	*Acer platanoides*
Ulmus pumila	*Gleditsia triacanthos*	*Cercis canadensis*	*Acer saccharum*
	Spiraea x vanhouttei	*Cornus florida*	*Magnolia x soulangiana*
	Syringa vulgaris	*Viburnum carlesii*	*Prunus x cistena*

Plant	Pest	Developmental Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V); remove tents
Birch	Birch leafminer	Larvae (visible as small blotches in leaves)
Cedar	Fletcher scale	Nymphs (V)
Deciduous trees	Fall cankerworm	Larvae (V)
Dogwood	Dogwood borer	Larvae: l: ook for holes and fresh sawdust on trunk and large branches; destroy larvae
Euonymus	Euonymus webworm	Larvae (look for yellow larvae and webbing on shoots) (V)
Evergreens	Spruce budworm	Larvae (V)
	Spruce spider mite	Hatching nymphs (V)
Fir	Balsam twig adelgid	Nymphs (V)

Plant	Pest	Developmental Stage
Honeylocust	Honeylocust pod gall midge	Adults (V); monitor with sticky cards
Lilac	Lilac borer	Larvae (look for holes and fresh sawdust on trunk and large branches); destroy larvae
Maple	Gall mites and wasps	Adults, eggs on new leaves
Oak	Gypsy moth	Egg hatch (V) at first bloom of *Cercis canadensis*
Pine	European pine sawfly	Larvae (look for small, green larvae on new growth) (V)
	Pine bark aphid	Newly hatched nymphs (V)
	Pine spittlebug	Look for nymphs inside spittle masses on new growth; remove by hand
	White pine weevil	Larvae in terminals; prune out
	Zimmerman pine moth	Overwintering larvae (V)
Spruce	Cooley and eastern spruce gall adelgid	Nymphs found on undersides of buds (V)
	Spruce spider mite	Hatching mites (shake branch over paper and look for reddish to brown and black mites) (V)
Various deciduous trees	Gypsy moth	Eggs masses beginning to hatch
Various deciduous trees and shrubs	Scales, adelgids, mealybugs, mites	Inspect plants that were infested last year
Various nursery stock in field	White grubs	C-shaped grubs in soil around damaged roots
Viburnum	Snowball aphid	Nymphs (inspect new leaves) (V)
	Viburnum leaf beetle	Hatching larvae (inspect egg sites and leaf undersides) (V)
Yew	Fletcher scale	Nymphs (V)

[1]*GDD = Growing degree days. For more information, see page 52.*

TABLE 4–7. Monitoring for Mid-May to Late May (100–150 GDD[1] Base 10°C)

(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Prunus serotina	*Aesculus hippocastanum*	*Amelanchier laevis*
Sorbus aucuparia	*Gleditsia triacanthos*	*Cercis canadensis*
	Lonicera korolkowii	
	Ribes odoratum	
	Spiraea x vanhouttei	
	Syringa vulgaris	
	Viburnum lantana	

Plant	Pest	Developmental Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V); remove tents
Birch	Birch leafminer	Adults, then newly hatched larvae; look for small blotches in leaves for larvae (V)
Boxwood	Boxwood psyllid	Waxy, white nymphs on new foliage
Cedar	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
Deciduous trees	Fall cankerworm	Larvae (V)
Elm	Elm leafminer	Adults emerge (V)
Euonymus	Euonymus webworm	Larvae (look for yellow larvae and webbing on shoots) (V)
Evergreens	Spruce spider mite	Hatching nymphs (V)
Fir	Balsam twig adelgid	Nymphs (V)
Lilac	Lilac borer	Larvae (look for holes and fresh sawdust on trunk and large branches); destroy larvae
	Lilac leafminer	Larvae (look for new mines in leaves) (V)
Maple	Gall mites and wasps	Larvae hatching

Plant	Pest	Developmental Stage
Pine	European pine sawfly	Larvae (look for small, green larvae on new growth) (V)
	Pine needle scale	Egg hatch
	Pine spittlebug	Look for nymphs inside spittle masses on new growth; remove by hand
	White pine weevil	Larvae in terminals; prune out
Spruce	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow mites) (V)
Various deciduous trees	Gypsy moth	Larvae (V)
Various nursery stock in field	White grubs	Look for C-shaped grubs in soil around damaged roots
Viburnum	Snowball aphid	Nymphs on new leaves (V) (they are only vulnerable to chemical control 1–10 days after egg hatch)
	Viburnum leaf beetle	Hatching larvae (inspect egg sites and leaf undersides) (V)
Yew	Taxus mealybug	Small, whitish nymphs (V) in branch crotches

[1]GDD = Growing degree days. For more information, see page 52.

TABLE 4–8. Monitoring for Late May to Early June (150–200 GDD[1] Base 10°C)
(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Cornus alternifolia	*Aesculus hippocastanum*	*Aesculus hippocastanum*
Prunus serotina	*Lonicera korolkowii*	*Gleditsia triacanthos*
Viburnum opulus	*Prunus serotina*	*Lonicera korolkowii*
	Sorbus aucuparia	*Ribes odoratum*
Ripe Seed	*Spirea x vanhouttei*	*Viburnum lantana*
Ulmus pumila	*Syringa vulgaris*	
		Candling (15–20 cm)
Dropping Seed		*Pinus mugo*
Acer saccharinum		

TABLE 4–2 Monitoring for Late May to Early June (150–200 GDD[1] Base 10°C) *Continued*

(V) indicates this pest is vulnerable to chemical control.

Plant	Pest	Developmental Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V); remove tents
Ash and other deciduous trees	Oystershell scale	Crawlers (V)
Birch	Birch leafminer	Larvae (look for small blotches in leaves) (V)
	Bronze birch borer	Treat bark with registered contact insecticides before eggs are laid
Boxwood	Boxwood psyllid	Waxy, white nymphs
Cedar	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
Deciduous trees	Fall cankerworm	Larvae (V)
Euonymus	Euonymus webworm	Larvae (look for yellow larvae and webbing on shoots) (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Holly	Holly leafminer	Small, grey, adult flies (V); use sticky traps to trap
Honeylocust	Honeylocust plant bug	Nymphs and adults (look for tiny, green plant bugs; adults have wings) (V)
Lilac	Lilac borer	Adult flight (as lilacs begin to bloom), mating and egg-laying; treat trunk and large branches with registered pesticides
	Lilac leafminer	Larvae (look for new mines in leaves) (V)
Maple	Gall mites and wasps	Larvae inside leaf galls
Pine	European pine sawfly	Small, green larvae on new growth (V) when the *Aesculus carnea* starts to bloom
	Pine needle scale	Tiny, red crawlers (V)
	Pine spittlebug	Look for nymphs inside spittle masses on new growth and remove by hand
	White pine weevil	Larvae in terminals; prune out

Plant	Pest	Developmental Stage
Spruce	Spruce gall adelgid	Egg hatch
	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow mites) (V)
Various deciduous trees	Gypsy moth	Larvae (V)
Various nursery stock in field	White grubs	C-shaped grubs in soil around damaged roots
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Willow	Imported willow leaf beetle	Adult emergence
Yew	Taxus mealybug	Small, whitish nymphs (V) in branch crotches

[1]*GDD = Growing degree days. For more information, see page 52.*

TABLE 4–9. Monitoring for Early June to Mid-June (200–250 GDD[1] Base 10°C)
(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Spiraea nipponica	*Aesculus hippocastanum*	*Aesculus hippocastanum*
Viburnum dentatum	*Cornus alternifolia*	*Gleditsia triacanthos*
Weigela florida	*Lonicera korolkowii*	*Lonicera korolkowii*
	Prunus serotina	*Ribes odoratum*
Ripe Seed	*Robinia pseudoacacia*	*Viburnum lantana*
Ulmus pumila	*Sorbus aucuparia*	
	Spirea x vanhouttei	**Candling (15–20 cm)**
Dropping Seed	*Syringa vulgaris*	*Pinus mugo*
Acer saccharinum	*Viburnum opulus*	

Plant	Pest	Developmental Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V); remove tents
Ash and other deciduous trees	Oystershell scale	Crawlers (V)

TABLE 4–9. Monitoring for Early June to Mid-June (200–250 GDD[1] Base 10°C) *Continued*

(V) indicates this pest is vulnerable to chemical control.

Plant	Pest	Developmental Stage
Birch	Birch leafminer	Larvae (examine second flush of leaves for small blotches) (V)
	Bronze birch borer	Adults; finish bark applications before eggs are laid
Boxwood	Boxwood psyllid	Waxy, white nymphs on new foliage
Cedar	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Elm	Elm leaf beetle	Larvae that cause holes and skeletonize foliage (V)
Euonymus	Euonymus scale	Crawlers hatch (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Holly	Holly leafminer	Small, grey, adult flies (V); use sticky traps to trap
Honeylocust	Honeylocust plant bug	Adults (look for tiny, green bugs with wings) (V)
Larch	Larch casebearer	Adults (look for tiny moths with dark wings that are easily disturbed)
Lilac	Lilac borer	Adult flight, mating and egg-laying; treat trunk and large branches with registered pesticides (V)
	Lilac leafminer	Larvae (look for new mines in leaves) (V)
Maple	Gall mites and wasps	Larvae inside leaf galls
Mountain Ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Pine needle scale	Tiny, red crawlers (V)
	White pine weevil	Larvae in terminals; prune out
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)

Plant	Pest	Developmental Stage
Spruce	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow-moving mites) (V)
Various deciduous trees	Gypsy moth	Larvae (V)
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Yew	Black vine weevil	Early emergence of overwintering adults (V)
	Taxus mealybug	Small, whitish nymphs (V) in branch crotches

[1]GDD = Growing degree days. For more information, see page 52.

TABLE 4–10. Monitoring for Mid-June (250–300 GDD[1] Base 10°C)

(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Kolkwitzia amabalis	*Cornus alternifolia*	*Aesculus hippocastanum*
Philadelphus	*Robinia pseudoacacia*	*Lonicera korolkowii*
	Spiraea nipponica	*Prunus serotina*
Ripe Seed	*Viburnum dentatum*	*Sorbus aucuparia*
Ulmus pumila	*Viburnum opulus*	*Spirea x vanhouttei*
	Weigela florida	*Syringa vulgaris*
Dropping Seed		
Acer saccharinum		

Plant	Pest	Developmental Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V); remove tents
Ash and other deciduous trees	Oystershell scale	Crawlers (V)
Birch	Bronze birch borer	Finish bark applications before eggs are laid
	Birch leafminer	Larvae (examine second flush of leaves for small blotches in leaves) (V)

TABLE 4–10. Monitoring for Mid-June (250–300 GDD[1] Base 10°C) *Continued*

(V) indicates this pest is vulnerable to chemical control.

Plant	Pest	Developmental Stage
Boxwood	Boxwood psyllid	Waxy, white nymphs on new foliage
Cedar	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Cherry	Peach tree borer	Newly hatched larvae (V)
Elm	Elm leaf beetle	Larvae that cause holes and skeletonize foliage (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Holly	Holly leafminer	Small, grey, adult flies (V); use sticky traps to trap
Larch	Larch casebearer	Adults (look for tiny moths with dark wings that are easily disturbed)
Lilac	Lilac borer	Adult flight, mating and egg-laying; treat trunk and large branches with registered pesticides (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Pine needle scale	Tiny, red crawlers (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Spruce	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow-moving mites) (V)
Various deciduous trees	Gypsy moth	Larvae (V)
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Yew	Black vine weevil	Early emergence of overwintering adults (V)
	Taxus mealybug	Small, whitish nymphs (V) in branch crotches

[1]*GDD = Growing degree days. For more information, see page 52.*

TABLE 4-11. Monitoring for Mid-June to Late June (300–400 GDD[1] Base 10°C)

(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Catalpa speciosa	*Catalpa speciosa*	*Aesculus hippocastanum*
Syringa reticulata	*Kolkwitzia amabalis*	*Cornus alternifolia*
Syringa villosa	*Philadelphus*	*Kolkwitzia amabalis*
	Syringa reticulata	*Robinia pseudoacacia*
	Viburnum dentatum	*Spiraea nipponica*
		Viburnum opulus

Plant	Pest	Developmental Stage
Ash and other deciduous trees	Oystershell scale	Crawlers (V)
Birch	Bronze birch borer	Larvae hatching and boring into bark
Cedar	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Cherry	Peach tree borer	Adults
Elm	Elm leaf beetle	Larvae that cause holes and skeletonize foliage (V)
Euonymus	Euonymus scale	Tiny, orange crawlers on twigs and leaf undersides (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Juniper	Juniper scale	Tiny, yellow nymphs (V)
Larch	Larch casebearer	Adults (look for tiny moths with dark wings that are easily disturbed)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Spruce	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow-moving mites) (V)
Yew	Black vine weevil	Early emergence of overwintering adults (V)

[1]*GDD = Growing degree days. For more information, see page 52.*

TABLE 4–12. Monitoring for Late June to Early July (400–500 GDD[1] Base 10°C)

(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Cirsium arvense	*Catalpa speciosa*	*Philadelphus*
Hydrangea arborescens 'Grandiflora'		*Syringa reticulata*
Sambucus canadensis	**Fruiting**	*Weigela florida*
	Amelanchier laevis	
	Lonicera tartarica	

Plant	Pest	Developmental Stage
Cedar	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Cherry	Peach tree borer	Adults
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Euonymus	Euonymus scale	Second-generation of eggs start to hatch (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Juniper	Juniper scale	Tiny, yellow nymphs (V)
Maple	Cottony maple scale	Crawlers hatching (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Yew	Black vine weevil	Early emergence of new-progeny adults (V)

[1]*GDD = Growing degree days.* *For more information, see page 52.*

TABLE 4–13. Monitoring for Early July to Mid-July (500–700 GDD[1] Base 10°C)

(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Cichorium intybus	*Cirsium arvense*	*Catalpa speciosa*
Daucus carota	*Daucus carota*	*Hydrangea arborescens* 'Grandiflora'
	Hydrangea arborescens 'Grandiflora'	*Yucca filamentosa*
Fruiting	*Sambucus canadensis*	
Lonicera tartarica	*Yucca filamentosa*	

Plant	Pest	Developmental Stage
Ash, other deciduous trees	European fruit lecanium scale	Crawlers (V)
Cedar	Fletcher scale	Crawlers (V)
	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Elm	European elm scale	Crawlers (V)
Euonymus	Euonymus scale	Egg-laying, egg hatch (second generation) (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Juniper	Juniper scale	Tiny, yellow nymphs (V)
Maple	Cottony maple scale	Crawlers on leaves and twigs (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Roses, grape vine	Japanese beetle	Adult beetles that skeletonize foliage (V)

TABLE 4–13. Monitoring for Early July to Mid-July (500–700 GDD[1] Base 10°C) ***Continued***
(V) indicates this pest is vulnerable to chemical control.

Plant	Pest	Developmental Stage
Spruce	Spruce bud scale	Crawlers (V)
Various ornamentals	Leafhoppers	Monitor *Caragana* and *Acer* as indicator plants; treat with insecticides at first sign (V)
Yew	Black vine weevil	Early emergence of new-progeny adults (V)
	Fletcher scale	Crawlers (V)

[1]GDD = Growing degree days. For more information, see page 52.

TABLE 4–14. Monitoring for Mid-July to Late July (700–900 GDD[1] Base 10°C)
(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Cichorium intybus	*Daucus carota*	*Daucus carota*
Daucus carota		
Hibiscus syriacus	**Fruiting**	
	Viburnum lantana	
Yellow Fruit	**Ripe Seed**	**White Flowers Turning Green**
Sorbus aucuparia	*Cirsium arvense*	*Hydrangea arborescens* 'Grandiflora'

Plant	Pest	Developmental Stage
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches; manually remove
Cedar	Strawberry root weevil	Adult weevils feed on new shoots, girdling them at the base
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Euonymus	Euonymus scale	Second-generation crawlers (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)

Plant	Pest	Developmental Stage
Pine	Pine needle scale	Second-generation crawlers (V)
	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Roses, grape vine	Japanese beetle	Adult beetles that skeletonize foliage (V)
Various ornamentals	Leafhoppers	Monitor *Caragana* and *Acer* as indicator plants; treat with insecticides at first sign (V)
Yew	Black vine weevil	Early emergence of new-progeny adults (V)

[1]*GDD = Growing degree days. For more information, see page 52.*

TABLE 4–15. Monitoring for Early August to Late August (900–1,100 GDD[1] Base 10°C)
(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Solidago canadensis	*Hibiscus syriacus*	*Hydrangea paniculata* 'Grandiflora'
	Hydrangea paniculata 'Grandiflora'	
	Solidago canadensis	**Fruiting**
Orange Fruit		*Viburnum lantana*
Sorbus aucuparia		*Viburnum opulus*

Plant	Pest	Developmental Stage
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches: manually remove
Cedar	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Cherry	Peach tree borer	Larvae
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Euonymus	Euonymus scale	Second generation of crawlers (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)

TABLE 4–15. Monitoring for Early August to Late August (900–1,100 GDD[1] Base 10°C) *Continued*
(V) indicates this pest is vulnerable to chemical control.

Plant	Pest	Developmental Stage
Magnolia	Magnolia scale	Egg hatch just beginning
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Roses, grape vine, various ornamentals	Japanese beetle	Adult beetles that skeletonize foliage
Various ornamentals	Leafhoppers	Monitor *Caragana* and *Acer* as indicator plants; treat with insecticides at first sign (V)
Yew	Black vine weevil	Early emergence of new-progeny adults (V)

[1]*GDD = Growing degree days. For more information, see page 52.*

TABLE 4–16. Monitoring for Late August to Mid-September (1,100–1,300 GDD[1] Base 10°C)
(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
		Solidago canadensis
Orange Fruit	**White Flowers Turning Pink**	
Sorbus aucuparia	*Hydrangea paniculata* 'Grandiflora'	

Plant	Pest	Developmental Stage
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches; manually remove
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Euonymus	Euonymus scale	Second generation of crawlers (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Magnolia	Magnolia scale	Crawlers (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)

Plant	Pest	Developmental Stage
Roses, grape vine, various ornamentals	Japanese beetle	Adult beetles that skeletonize foliage
Various ornamentals	Leafhoppers	Monitor *Caragana* and *Acer* as indicator plants; treat with insecticides at first sign (V)

[1]GDD = Growing degree days. For more information, see page 52.

TABLE 4–17. Monitoring for Mid-September to Late October (1,300–1,700 GDD[1] Base 10°C)
(V) indicates this pest is vulnerable to chemical control.

Early Bloom	Full Bloom	Late Bloom
Hamamelis virginiana	*Hamamelis virginiana*	*Solidago canadensis*
Solidago sp.	*Solidago* sp.	
Fruiting	**Fall Foliage Colour**	**Ripe Seed**
Viburnum dentatum	*Acer saccharum*	*Daucus carota*

Plant	Pest	Developmental Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Shiny, grey egg mass bands on small twigs; prune out
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches; manually remove
Cherry	Peach tree borer	Larvae; examine cankered regions and remove infested plants
Evergreens	Spruce spider mite	Shake branches over white paper and look for tiny, slow-moving mites (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Pine	Zimmerman pine moth	Larvae (V)
Spruce	Cooley and eastern spruce gall adelgid	Tiny, grey, fuzzy nymphs next to buds (vulnerable when the *Acer saccharum* are in fall colour)
	Spruce spider mite	Shake branches over white paper and look for tiny, slow-moving mites (V)
Various woody ornamentals	Overwintering insects and mites	Overwintering scales, mites, mealybugs and adelgids; flag affected plants for dormant oil application

[1]GDD = Growing degree days. For more information, see page 52.

Diseases Affecting Trees and Shrubs

Diseases are broadly classified according to the types of damage they cause to woody plants. Categories include foliar diseases, crown and root rots, cankers, vascular wilts, viruses and abiotic diseases

Diseases can be caused by many factors such as bacteria, fungi, moulds, viruses and environmental conditions. Some common nursery and landscape plant diseases are listed below. As well, see *A Compendium of Pests and Diseases with Recommended Management Practices* on page 94.

Foliar Diseases

Most disease symptoms appear first in plant foliage. However, damaged foliage may not necessarily mean there is a leaf disease. Leaves may wilt, turn yellow or brown, spot, drop off or deform due to diseases not directly associated with the leaves. For example, plant foliage can change in response to vascular wilts or cankers elsewhere on the plant. Non-infectious agents such as drought, wet soil (overwatering) and air pollution can also cause disease-like symptoms on the foliage. Quite often root problems aren't detected until foliar symptoms begin to appear. Before diagnosing any plant problem, always check that the roots are white and firm, not brown and mushy.

Most foliar diseases develop in response to high humidity and extended periods of leaf wetness. Schedule irrigation so that crops that are sensitive to foliar diseases are only watered in the early to mid-morning, never late in the day or at night. This will ensure the shortest possible periods of leaf wetness.

Downy mildew, powdery mildew, leaf spots, anthracnose and needlecast are common diseases that infect foliage directly. Rust diseases that cause leaf spots on broadleaf hosts are also discussed under *cankers* (due to their symptoms on the alternate host).

Botrytis (Grey Mould)

This disease, caused by the fungus *Botrytis cinerea*, can affect bulbs, stems, leaves and flowers. It often attacks open or fading flowers and leaves, succulent soft growth and damaged tissue. Symptoms vary from host to host. In very humid air, botrytis causes a fuzzy grey growth on infected plant parts.

High humidity promotes botrytis outbreaks. Reduce humidity by providing good air circulation around plants. Remove all fading, senescing and diseased plant parts promptly, especially when wet weather is predicted. Avoid overhead irrigation late in the day and never leave old leaves or flowers on plants or on the surrounding soil surface.

Downy Mildew

Downy mildew appears early in the season. Under very high humidity, it can produce grey to brown downy growth (sporulation) on the undersides of leaves. Once the humidity drops (by mid-morning, for example), the downy growth will disappear. Discoloured, purplish, angular spots may appear on the upper surface of the leaves.

Warm or cool wet weather and poor air circulation promote downy mildew. Reduce humidity by providing good air circulation around plants. Remove all fading, senescing and diseased plant parts promptly, especially when wet weather is predicted. Avoid overhead irrigation late in the day and never leave old leaves or flowers on plants or on the surrounding soil surface.

Powdery Mildew

Several species of fungi cause powdery mildew. Powdery mildews produce powdery white mats on upper leaf surfaces and young tissue. Wind-borne spores can cause secondary infections, although individual species do not spread readily from one kind of plant to another.

Powdery mildew usually appears after the mid-season, when warm days follow cooler nights. It affects many woody ornamentals, such as *Syringa, Rosa, Ligustrum* and *Amelanchier, and several herbaceous perennials.* Because the fungus grows mainly on the plant surface, it can be managed with fungicides at the first sign of symptoms. In some cases, as with roses, severe deformation may result.

To reduce powdery mildew, place plants in sunny locations with good air circulation. Where possible, plant resistant cultivars. Overhead watering during the day may reduce the spread and development of powdery mildew. Avoid overhead irrigation late in the day, as this will promote spore development at night.

Leaf Spot and Anthracnose

"Anthracnose" refers to several plant diseases that cause dead spots on leaves or fruits. This disease may also affect the twigs, causing a canker and dieback. Infected areas may coalesce into large necrotic spots as the disease spreads. In severe cases, this condition defoliates the plant. Leaf spotting itself is not harmful. However, extensive annual defoliation year after year can lead to plant decline and death.

Cool, wet, cloudy spring weather promotes infection by fungi that cause leaf spot and anthracnose. *Catalpa, Populus, Juglans, Carya, Crataegus, Acer, Quercus, Platanus (Sycamore), Philadelphus, Sorbus* and *Aesculus* are common hosts. Sycamore anthracnose (*Gnomonia plantani*) can be severe in Ontario and has been linked to the death of many trees in the eastern United States.

Needlecast

Needlecast diseases are fungi affecting pines (*Pinus*), spruce (*Picea*) and firs (*Abies*). New needles generally become infected just after the new growth starts. Tiny black fruiting bodies may develop along the infected needles, often in place of the tiny white stomates. Needles infected the previous season are "cast" (i.e., fall off) during the summer. Needlecast can be serious in 1–4-year-old plants at Ontario tree nurseries.

Apple Scab

"Scab" describes a fungus disease on fruit, although a leaf spot similar to blackspot on rose has the same cause. This disease causes purplish blotches on leaves of *Malus.*

Apple scab (*Venturia inaequalis*) can lead to the defoliation of crabapples when cool, wet weather occurs in mid-to-late spring. Control apple scab through cultural practices. Plant the trees in open, sunny areas with good air movement and maintain their health. Prune the trees regularly to encourage quick leaf drying. Since the disease overwinters on fallen leaves, collect these leaves in the late summer and remove them from the area. This practice may prove ineffective if other diseased trees are growing nearby. If leaf removal is not possible, try using a mower to mulch leaves as they drop throughout the autumn season. The smaller leaf sections will accelerate bacterial breakdown, resulting in fewer fungal fruiting bodies to produce infective spores the following spring.

With proper culture, apple scab rarely requires chemical control. Where possible, plant scab-resistant crabapple cultivars. If cool, wet weather persists and/or scab symptoms begin to appear, apply registered fungicides. Apply the first spray when the green leaf tips appear. Repeat every 7–10 days until the *Catalpa speciosa* begin bloom (end of June). If no scab appears by then, stop spraying. If scab is visible, continue fungicide applications every 10–14 days until mid-August.

Pyracantha Scab

Pyracantha scab *(Venturia pyracanthae)* destroys the fruit of susceptible firethorn varieties. Spraying is necessary most years. The cultivars 'Orange Glow,' 'Orange Charmer' and 'Mohave' have some resistance to this disease.

Sudden Oak Death (Ramorum Blight)

Sudden Oak Death (SOD) is a disease caused by the pathogen *Phytophthora ramorum*, a fungus-like organism that thrives in cool, wet conditions. This is a serious disease that has been associated with the death of hundreds of thousands of oak trees in California since it was first detected in the 1990s. It is also responsible for the death of many trees in several European countries. Since its detection, SOD disease surveys have shown that this organism can infect and spread on over 65 genera of plants, many of which are grown as ornamental plants. Ornamental plants are traded widely between countries, and nursery stock has been identified as a major pathway of unnatural spread for SOD. Because of this, SOD-host nursery stock is regulated throughout parts of the world. In North America, this includes several counties of California and one in Oregon. Six high-risk genera that have been associated with the spread of SOD via nursery stock include *Camellia, Rhododendron, Viburnum, Pieris, Kalmia* and *Syringa*.

The Canadian Food Inspection Agency (CFIA) regulates the importation of SOD host nursery stock in Canada. These regulations can be found on the CFIA website in Directive, D-01-01, *Phytosanitary Requirements to Prevent the Entry of Phytophthora ramorum.* The list of plant genera regulated for *Phytophthora ramorum* can be found in Appendix 1 of this Directive.

For the most up-to-date information on Sudden Oak Death, contact your local Canadian Food Inspection Agency office (see Appendix C, *Other Contacts*, on page 196) or consult the CFIA website at www.inspection.gc.ca.

The British Columbia Nursery Landscape Association has its own SOD certification program to limit the spread of this disease. For more information, see "Nursery Programs" at www.canadanursery.com. Another excellent reference website is www.suddenoakdeath.org.

Crown and Root Rots

Soil fungi such as *Pythium* and *Phytophthora* cause the roots and crowns of many plants to rot. These fungi are most often associated with overwatering or media/soil with poor drainage. The lower leaf parts, petioles and stems of diseased plants develop a water-soaked appearance. Eventually, the plant rots off at ground level. For ornamentals, protectant fungicides (such as Subdue MAXX) can be incorporated into the media at time of potting to reduce *Pythium* and *Phytophthora* diseases.

Rhizoctonia and *Fusarium* fungi cause a brown cankering of plant stems and roots below ground. *Thielaviopsis* causes severe root rot in infected plants. Tissues affected by a *Thielaviopsis* infection are more black than brown, helping to distinguish it from other infections. When this condition affects seedlings, the disease is called "damping-off." *Thielaviopsis* is more common in floriculture crops than in nursery crops.

Cankers

Cankers kill bark and cambial tissues in localized branch and stem areas. Bark in affected areas splits as it dries and is easily removed, exposing the wood below. Subsequently, the underlying cambium and wood are killed. Fruiting "pustules" of the disease organism usually form on the dead bark areas. Cankers may girdle a stem or branch, killing portions of the plant.

Canker diseases can be annual or perennial. They commonly damage hosts weakened by factors such as drought, marginal hardiness, root disturbance or a poor root environment. Weak, parasitic fungi (species of *Cytospora, Nectria, Valsa* and *Hypoxylon*) cause damaging canker diseases that a healthy, vigorous host would resist by "sealing off" the infecting agent. While fungi account for most cankers, sunscald and freeze-thaw injury may also be responsible.

Some canker diseases (e.g., white pine blister rust, chestnut blight and butternut canker) can be very serious. "Monoculture" growing systems used in plantations and forest nurseries may promote serious canker diseases.

Chemical control for canker diseases is not always effective. Thoroughly prune diseased branches well below the affected areas. Remove and destroy infected material. For long-term management, improve host health and vigour using cultural means.

Rust

Rust diseases involve fungi that cause reddish-brown (rusty) spots on leaves, twigs or stems. They frequently distort the shape of infected plant parts. Some rusts have only one host plant but most require two hosts, each at a different phase of their life cycle. While both hosts are necessary for the disease organism to thrive, one host plant may be severely damaged while the other suffers little or no damage.

Bacterial Blights

Fire blight, a bacterial disease caused by *Erwinia amylovora*, affects many members of the *Rosaceae* family including *Amelanchier, Aronia, Chaenomeles, Cotoneaster, Crataegus, Malus, Photinia, Prunus, Pyracantha, Pyrus, Sorbus* and *Spiraea*. Flowers, spurs, twigs and leaves turn brown and dry out. Dead leaves remain on the plant and appear scorched. In warm, humid weather, an amber material may be exuded from recently infected parts. Bleeding perennial cankers may appear on limbs, trunks or roots as the infection spreads. Fire blight infections can be severe if conditions are warm and wet when the host trees are blooming. Rain, wind and insects can spread this disease from plant to plant. Manage fire blight by pruning cankers 0.3 m below the affected area when the trees are dormant and by removing nearby infection sources, such as neglected apple or pear trees. Always disinfect pruning instruments after each cut. Bactericidal sprays at flowering may be helpful. For more information, see OMAFRA Publication 360, *Fruit Production Recommendations*.

Bacterial blight (*Pseudomonas syringae pv. syringae*) has been linked to dieback on container nursery stock. Many deciduous, woody shrubs including lilacs (*Syringa*), mock orange (*Philadelphus*) and ornamental cherry (*Prunus*) are susceptible to this bacteria. Symptoms first appear when container stock is uncovered in the spring, revealing blackened shoots and buds that have been killed. Extreme changes in temperature coupled with extended periods of leaf wetness seem to encourage the development of bacterial blight in container production. Some growers have reduced disease incidence by installing drip irrigation systems to keep foliage dry and delaying the removal of poly cover over high-value, susceptible stock. Applications of bactericides after leaves drop in the autumn, and again as the buds begin to swell and break during spring, can help reduce disease pressure.

Crown Gall

The bacterium *Agrobacterium tumefaciens* causes rough, irregular galls up to several centimetres in size. Crown gall can affect most woody plants, including rosaceous hosts, euonymus, willow and nut trees. It occurs mainly near the soil line at the root collar, but also on roots and aerial parts such as top-grafted willow stems. While not a "true" canker disease, crown gall is included in this section because it disrupts the plant's vascular system, resulting in girdling.

The bacterium can live in the soil without host plants for about 2 years. It the plant enters through wounds such as those caused by a disc, hoe, pruning shears or grafting knife. Incidence of crown gall on susceptible top-grafted standards (e.g., *Salix*) can be limited by growing in polyhouses. Nurseries should use sanitary propagation practices such as sterilizing grafting tools after each cut. Remove or replace infested soils, or leave them fallow for 2 years before replanting. Chemical controls are not always effective.

Vascular Wilts

Fungi or bacteria entering a plant's vascular system can reduce water supplied to the leaves, causing wilt. In the early stages of wilt, leaves may recover temporarily during cool, moist periods. Eventually, the wilt becomes established and the leaves and twigs die, leading to branch mortality and the eventual death of the entire plant. Serious vascular wilt diseases include Dutch elm disease (*Ceratocystis ulmi*) and verticillium wilt (*Verticillium dahliae*).

To avoid wilt diseases, use resistant plant cultivars and grow susceptible crops in disease-free soil. See Table 4–18 and Table 4–19 on page 86. Sometimes it is possible to maintain plants infected with verticillium wilt by improving vigour through pruning, fertilizing and watering. Since these disease organisms live in the plant, surface application of fungicides will not be effective. *Verticillium* is a soil-borne fungus that persists in the soil for many years. Verticillium wilt has been associated with field-grown trees where root systems were repeatedly wounded by cultivation or pruning. When considering a field for the production of *Verticillium*-susceptible trees, test soil for *Verticillium* populations first.

TABLE 4–18. Woody Plants Resistant to Verticillium Wilt

All monocots (grass-like) plants	
All conifers	
The following broadleaf plants:	
Betula	birch
Carya	hickory
Celtis	hackberry
Cercidiphyllum	katsura tree
Chaenomeles	flowering quince
Cornus	dogwood
Crataegus	hawthorn
Fagus	beech
Gleditsia	honeylocust
Ilex	holly
Juglans	butternut, walnut
Liquidambar	sweetgum
Malus	apple, crabapple
Morus	mulberry
Platanus	plane tree, sycamore
Populus	poplar
Pyracantha	firethorn
Pyrus	pear
Quercus	oak
Rhododendron	rhododendron
Salix	willow
Sorbus	mountain ash
Tilia	linden
Zelkova	Japanese zelkova

TABLE 4–19. Woody Plants Susceptible to Verticillium Wilt

Acer	maple
Aesculus	buckeye, horsechestnut
Amelanchier	serviceberry
Buxus	boxwood
Calluna	heath
Catalpa	catalpa
Cercis	red bud
Cladrastus	yellowwood
Cotinus	smokebush
Daphne	daphne
Eleagnus	Russian olive
Fraxinus	ash
Gymnocladus	Kentucky coffee tree
Hibiscus	hibiscus
Koelreuteria	golden rain tree
Ligustrum	privet
Liriodendron	tulip tree
Lonicera	honeysuckle
Magnolia	magnolia
Phellodendron	cork tree
Prunus	cherry and other stone fruit
Rhododendron	azalea
Rhus	sumac
Ribes	currant, gooseberry
Robinia	black locust
Rosa	rose
Sambucus	elder
Spiraea	spirea

Syringa	lilac
Ulmus	elm
Viburnum	viburnum
Vitis	grape vine
Wiegela	wiegela

Virus Diseases

Virus diseases appear on plants as mottled yellow foliage, misshapen or wrinkled leaves, aborted flowers or stunted growth. There are no effective pesticides against viruses. Remove diseased plants and destroy them to prevent the virus from spreading to the rest of the block.

Insects and infected tools such as pruning equipment, knives and shears are the means by which most viral diseases spread. Reduce levels of sucking insects such as aphids, thrips, leafhoppers and mites to reduce the spread of viral diseases. Disinfect all tools and implements before using them again. Samples of symptomatic plants can be sent to the Pest Diagnostic Clinic (see Appendix D, *Diagnostic Service*, on page 198) to analyze for virus particles. Destroy infested plants where possible to prevent further spread to other susceptible crops.

Ash Yellows

Plants show reduced growth, stunting and smaller leaves. Symptoms can vary with the age of the plant. In some cases, plants develop chlorotic leaves and witches' brooms (a proliferation of shoots at the tips of branches).

Elm Yellows

Leafhoppers probably transmit these mycoplasma-like organisms. Leaves of infected trees begin to turn yellow, twist and exhibit droop (epinasty) by mid summer. The infected leaves often drop, and the branch dies shortly after.

Rose Mosaic

Rose mosaic symptoms can include leaf discolouration, chlorotic mottling, ring spots, light green or chlorotic line patterns, vein clearing, banding and white or yellow mosaics. Specific symptoms vary with the cultivar, the environment and the strain of virus.

Abiotic Diseases

Abiotic diseases principally affect foliage and/or root system function. They are usually related to extreme environment (too hot, too dry, too wet, etc.). These diseases cause many plant problems, often predisposing affected plants to attack by secondary disease organisms. The result can be gradual dieback and death.

Weather, soil conditions and human environmental disturbances cause these conditions. Control measures depend on eliminating or avoiding damaging factors (e.g., salt injury), obtaining resistant plants and improving growing conditions.

Root scorch from high soil-salt levels is a common abiotic condition. It is the result of salty groundwater or run-off containing salt applied to nearby roads to melt ice and snow. Sudden exposure to full sunlight after a cloudy, wet period can cause late-spring leaf scorch in *Acer* and *Fagus*.

The ability of a plant to accommodate environmental change varies with the type of plant, its age and condition, and the nature and intensity of the changes. Oak, maple, ash and spruce have difficulty adjusting to new conditions such as soil compaction, drought, excessive water (reduced aeration in the root zone), change in soil level or root damage during construction. Exotic species such as Norway spruce may not be as well adapted to our climate as native species.

Understanding Dieback

Nursery and landscape ornamentals often exhibit dieback of leaves and small branches. Symptoms may appear on individual branches or entire plants. Dieback may appear suddenly or develop so gradually that the true impact does not show for several years.

Some of the environmental and cultural causes of dieback include girdling wires, strings and ropes left on after transplanting. Root problems, soil conditions, waterlogging, changes in soil grade, sunscald and freeze-thaw temperatures may also be at fault.

Light-to-moderate infestations of insects and diseases can also cause dieback symptoms. Some examples include scale insects, wood-boring insects, bark-boring insects, root-feeding weevils, white grub larvae, cankers, rusts, fire blight and vascular wilts.

Fall Needle Drop of Conifers

As shorter, cooler autumn days approach, older needles towards the inside of many conifers begin to turn yellow or brown. In some cases, these needles start to drop. Although this is usually a natural process, the degree of discolouration and leaf drop may relate to stress during the growing season. Low vigour caused by drought, transplanting, poor drainage, soil compaction, insects and disease make needle drop worse. Pines lose their oldest needles (closest to the trunk). White pines (*Pinus strobus*) often lose needles that are 2 years old or older. Branchlets of Eastern white cedar (*Thuja occidentalis*) often turn brown on the inside of the branches and fall off. Fir (*Abies*) and spruce (*Picea*) may lose needles on 1–3-year-old wood.

Needle Browning on Conifers

Winter damage may cause conifer needles to turn brown and drop in the spring. Many factors can lead to this condition, especially dry, windy weather while the soil is frozen. Roots cannot absorb enough water from the frozen soil to compensate for the foliar desiccation caused by winter winds. Warm afternoon temperatures in late winter can also contribute to foliar water loss.

Good growing conditions during the previous growing season help plants resist winter damage. Roots in the upper soil surface are sensitive to drying and high temperatures. If these roots die during the growing season, they may not be able to store enough water to recover from moisture losses during the winter.

Salt Damage

Woody plants are affected by road salt, both from run-off into the soil and airborne spray created by traffic. Salty run-off from sidewalks and roadways can accumulate in the soil around the root system and lead to physiological drought in the plant.

When plant tissues are wet and temperatures are above freezing, sodium and chloride ions (the most common ingredients in road salt) enter plant tissues and accumulate. Repeated road salt injury weakens plants, making them susceptible to damage from many insects and diseases.

Salt spray causes more plant damage than run-off. It can affect plants located 100 or more metres away from a road. Symptoms appear more quickly in warm weather and are usually more severe on the side facing the road. Evergreen foliage and dormant buds can absorb salts and be killed.

Salt Damage Symptoms on Conifers

Symptoms of salt damage on conifers include:

- needle browning, beginning at the tip
- needle browning and twig dieback on the side facing the road, with little or none on the opposite side
- no needle browning or dieback on branches near the ground under continuous snow cover
- needle and twig dieback that is less severe the further the tree is from the road
- browning that appears in late February or early March and becomes more obvious through spring and summer

Salt Damage Symptoms on Deciduous Plants

Symptoms of salt damage on deciduous plants include:

- slow bud break on terminal parts of branches facing the road
- leaves that fail to emerge on terminal parts of branches facing the road
- new growth on branches facing the road that develops lower, dormant buds, causing a tufted or witches' broom appearance
- flower buds facing the road side that do not open, while normal flowering occurs on plants further away from the road
- injury that becomes evident as buds begin to break

Scorch

Scorch happens when plants have difficulty taking up water, usually during hot, dry weather. It appears as sudden leaf death or browning on leaf margins or between leaf veins, often in the heat of the summer. The veins frequently remain green.

Plants experiencing root injury due to construction, soil compaction, chemicals, drought or extreme heat can also show symptoms of scorch.

Using Pesticides

Classification of Pesticides for Sale and Use in Ontario

In April 2009, the Ministry of Environment amended the *Pesticides Act* with the *Cosmetic Pesticides Ban Act*, 2008 and Ontario Regulation 63/09. Pesticides are now classified for sale and use under 11 different classes. It should be noted that agriculture (e.g., nursery production) is excepted. For more information on the legislation, see the Ministry of the Environment's website at www.ontario.ca/pesticideban.

Toxicity Information

The "relative toxicity" of a pesticide is called its LD_{50}. The higher the LD_{50} value of a chemical, the less toxic the product is to humans.

LD50 is the chemical's active ingredient (a.i.) in mg/kg of test animal body weight that kills 50% of the test animals (usually female rats). LD_{50} is commonly measured as the **Acute Oral LD_{50}**, which means the chemicals are ingested through the mouth or nose. **Dermal LD_{50}** (skin penetration) toxicity values are available on request.

Chemical Families

Most agricultural chemicals belong to a chemical "family," a group of substances that share important characteristics. To prevent pests from becoming resistant to a particular product, rotate among chemicals from different chemical families.

The product tables on the following pages list chemical families using abbreviations and full chemical family names.

TABLE 4–20. Chemical Families

Abbr	Full Name	Abbr	Full Name	Abbr	Full Name
An	aliphatic nitrogenous compound	EBI	ergosterol biosynthesis inhibitor	Ph	phthalimide
Ani	anilide	Hort	horticultural oil	Phen	phenylamide
Arom	aromatic hydrocarbon	IGR	insect growth regulator	Pyr	pyridazone
Ben	benzimidazole	Ino	inorganic	Pyr Azo	pyridine azomethine
Bio	biological	Min	mineral	Pyre	pyrethroid
Car	carbamate	Morph	morphactin	R	rodenticide
Chl	chloronicotinyl	Nat	naturalyte	Str	strobilurin
Cz	carbazate	OC	organochlorine	Syn Pyr	synthetic pyrethroid
Dicarb	dicarboximide	OP	organophosphate	Tetr	tetrazine, mite growth inhibitor
Dinitro	dinitrophenol	Org	organatin	Thia	thiadiazole
Dithio	dithiocarbamate	OX	oxithin	Tri	triazole

TABLE 4–21. Insecticides and Fungicides Used to Protect Ornamentals
(by Product Name)

Product Name	Type*	Common Name	Oral LD_{50} (mg a.i./kg)	Chemical Family	Group**
Acrobat	F	dimethomorph	4,300	cinnamic acid amides	40
Apollo SC	A	chlofentezine	> 5,000	tetrazine, mite growth inhibitor	10A
Arbotect 20-S	I	thiabendazole	> 5,000	benzimidazole	1
Banner MAXX	F	propiconazole	> 4,000	triazole	3
BGreen, Nemasys G	I	*Heterohabditis bacteriophora*		biological	
BioProtec	I	*Bacillus thuringiensis*	> 15,000	biological	
BlightBan C9-1	F	*Pantoea agglomerans* (strain C9-1)		biological	
Bloomtime Biological	F	*Pantoea agglomerans* (strain E325)		biological	
Botran 75W	F	dicloran	> 10,000	dicarboximide	14
Captan 50 WP	F	captan	9,000	phthalimide	M4
Chipco Aliette WG	F	fosetyl-al	2,860	ethyl phosphonates	U
Compass 50 WG	F	trifloxystrobin	> 5,050	strobilurin	11
Confirm 240 F	I	tebufenozide	> 5,000	insect growth regulator	18
Copper	F	copper sulphate	472	inorganic	M1
Copper Spray	F	copper oxychloride		inorganic	M1
Daconil 2787	F	chlorothalonil	> 10,000	chloronitrile	M5
Daconil Ultrex	F	chlorothalonil	> 10,000	chloronitrile	M5
Deadline	M	metaldehyde	250		
Decree	F	fenhexamid	> 5,000	anilide	17
Diazinon	I	diazinon	300	organophosphate	1B

Product Name	Type*	Common Name	Oral LD_{50} (mg a.i./kg)	Chemical Family	Group**
Dipel	I	*Bacillus thuringiensis*	> 15,000	biological	11
Dithane DG	F	mancozeb	> 5,000	dithiocarbamate	M3
Dithane M-45	F	mancozeb	6,750	dithiocarbamate	M3
Dragnet FT	I	permethrin	998	synthetic pyrethroid	3
Dursban T	I	chlorpyrifos	135	organophosphate	1B
Dursban Turf	I	chlorpyrifos	135	organophosphate	1B
Dygall	F	*Agrobacterium radiobacter*		biological	
Dylox	I	trichlorfon	560	organophosphate	1B
Dyno-Mite	A, I	pyridaben	1,930	pyridazone	21
Eagle	F	myclobutanil	1,600	triazole	3
Endeavor 50 WG	I	pymetrozine	> 5,000	pyridine azomethine	9B
Equal 65 WP	F	dodine	1,000	aliphatic nitrogenous compound	M7
Ferbam 76 WDG	F	ferbam	> 17,000	dithiocarbamate	M3
Floramite SC	A	bifenazate	> 5,000	carbazate	25
Folpan 50 WP	F	folpet	10,000	phthalimide	M4
Foray	I	*Bacillus thuringiensis*	> 15,000	biological	11
Forbid	I	spiromesifen	> 2,000	lipid biosynthesis inhibitor	23
Funginex	F	triforine	> 16,000	ergosterol biosynthesis inhibitor	3
Ground Force	R	chlorophacinone	2.1		
Heritage	F	azoxystrobin	> 5,000	strobilurin	11
Imidan 50WP	I	phosmet	300	organophosphate	1B
Insecticidal Soap	I	potassium salts of fatty acids	> 5,000	insecticidal soap	

TABLE 4–21. Insecticides and Fungicides Used to Protect Ornamentals *Continued*
(by Product Name)

Product Name	Type*	Common Name	Oral LD_{50} (mg a.i./kg)	Chemical Family	Group**
Intercept 60WP	I	imidacloprid	1,858	chloronicotinyl	4A
Kanemite 15 SC	I	acequinocyl	> 5,000	naphthaquinone derivative	20B
Kelthane	A	dicofol	684	organochlorine miticide	3
Lagon 480 E	I	dimethoate	215	organophosphate	1B
Landscape Oil	I	mineral oil	> 15,000	horticultural oil	NC
Lannate	I	methomyl	17	carbamate	1A
Maestro 80 DF	F	captan	9,000	phthalimide	M4
Malathion	I	malathion	1,400	organophosphate	1B
Meltatox	F	dodemorph	4,500	morphactin	5
MilStop	F	potassium bicarbonate	2,700	inorganic	M1
Mimic 240 LV	I	tebufenozide	> 5,000	insect growth regulator	18
Nemasys H	I	*Heterohabditis megidis*		biological	
Nova	F	myclobutanil	1,600	triazole	3
Orthene	I	acephate	866	organophosphate	1B
Polyram	F	metiram	> 10,000	dithiocarbamate	M3
Pounce	I	permethrin	> 4,000	pyrethroid	3
Pyrate	I	chlorpyrifos	135	organophosphate	1B
Ramik Brown, Ramik Green	R	diaphacinone	3		
Ratak+	R	brodifacoum	0.27		
Ripcord 400 EC	I	cypermethrin	242	pyrethroid	3
Rhapsody		*Bacillus subtilis*		biological	
Rodent Bait, Rodent Pellets	R	zinc phosphide	45		
Rootshield	F	*Trichoderma harzianum*		biological	

Product Name	Type*	Common Name	Oral LD_{50} (mg a.i./kg)	Chemical Family	Group**
Rovral	F	iprodione	3,550	dicarboximide	2
Rozol	R	chlorophacinone			
Senator 70 WP	F	thiophanate-methyl	7,500	benzimidazole	1
Serenade Max	F	*Bacillus subtilis*		biological	
Sevin T&O	I	carbaryl	560	carbamate	1A
Sevin 50 W	I	carbaryl	560	carbamate	1A
Sluggo	M	ferric phosphate	> 5,000	mineral	
Subdue MAXX	F	metalaxyl-M and S-isomer	3,436	phenylamide	4
Success 480 SC	I	spinosad	> 2,000	naturalyte	5
Sulphur	F	sulphur	> 5,000	inorganic	M2
Supra Captan 80 WDG	F	captan	9,000	phthalimide	M4
Thiodan 4 EC	I	endosulfan	110	organochlorine	2A
Thionex	I	endosulfan	110	organochlorine	2A
Thiram	F	thiram	780	dithiocarbamate	M3
Thuricide	I	*Bacillus thuringiensis*	> 15,000	biological	11
Tristar 70 WSP	I	acetimiprid	1,064	chloronicotinyl	4A
Trounce	I	potassium salts of fatty acid and pyrethrin	> 5,000	insecticidal soap and botanical	
Truban	F	etridiazole	1,077	thiadiazole	14
Vectobac	I	*Bacillus thuringiensis* subsp. *israelensis*	> 15,000	biological	11
Vendex	A	fenbutatin oxide	2,631	organotin	12
Waxed Mouse Bait	R	zinc phosphide	45		

** I = Insecticide; F = Fungicide and/or bactericide; R = Rodenticide; A = Acaricide; M = Molluscicide*

*** Pesticide Group classifies the compound according to mode of action. This system helps the user rotate among pesticides with different modes of action in order to reduce the risk of resistance to a specific pesticide product.*

Pesticide Application Restrictions

According to *Ontario's Pesticides Act* and Regulation 63/09, pesticides cannot be used for cosmetic purposes on lawns, vegetable and ornamental gardens, patios, driveways, cemeteries or in parks and schoolyards. To learn more about the use and sale of pesticides in Ontario, visit the Ministry of the Environment website at www.ontario.ca/pesticideban. Search under "What you need to know" to find information for different users (homeowners, commercial operators, agriculture industry, etc.). Search under "Pesticide Classes and Database" to find the lists of pesticide products for each of the 11 pesticide classes.

A Compendium of Pests and Diseases with Recommended Management Practices

Listings appear alphabetically by plant genus. Pesticide products listed appear alphabetically. The order in which products appear does not constitute a preference ranking. See Table 4–21, *Insecticides and Fungicides Used to Protect Ornamentals (by Product Name)*, on page 90 for a list of pesticides registered on outdoor ornamentals and their chemical properties, such as toxicity. In cases where no product is listed, either a pesticide application would not be effective or there is no product registered. The "Notes" column contains information on pest biology and monitoring and additional remarks about the use of registered pesticides.

See Appendix G, *Colour Plates*, on page 205, for photos of plant pests.

ABIES — fir

	Pest	Product/1,000 L Water	Notes
INSECTS	Balsam twig aphid *(Mindarus abietinus)*	DZN 600 EW, see product label Endeavor 50 WG, 193 g/ha in 275 L water Malathion 500 EC, 1.25 L Tristar 70 WSP, 3 solupaks	The eggs overwinter on bark and hatch into first generation nymphs ("stem mothers") in early spring when bud caps begin to loosen. Second generation nymphs feed on newly developing needles, causing them to become distorted and discoloured. Treat when stem mothers first hatch. Second generation nymphs are more difficult to manage due to their protective waxy covering.
	Cutworms (various species)	Confirm 240F, 0.5 L/ha Dylox, 2.75–4 L/ha Pounce, 180 mL/ha	Cutworms are moth larvae (caterpillars) that hide in shallow soil burrows during the day and crawl up plant stems to harvest plant parts at night. Injury appears as chewed or girdled stems on woody species (and clipped stems on herbaceous plants). Larvae are greyish-brown in colour, often with black spots along their sides and stripes along their body. They have three pairs of true legs, four pairs of fleshy prolegs and one pair of "claspers" at the end of their abdomen. They can be up to 3 cm long. Late instar larvae overwinter and pupate in spring. Use insecticides to reduce cutworm populations at the first sign of feeding injury. Treat plants with insecticides in the evening since the larvae feed at night. Applications of Confirm should be made with a high-volume spray and sprayed to run-off (for greenhouse use). Applications of Pounce should be made under warm, moist conditions when larvae are small.
	June beetle *(Phyllophaga* sp.*)* European chafer *(Rhizotrogus majalis)* **[Plate 17]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L	These beetle larvae are referred to as "white grubs." They chew fibrous roots and girdle underground stems of many woody ornamentals (including *Cornus* sp.). Cultivate infested fields before planting to expose grubs to natural predators. Sevin T&O is registered as a foliar spray for adults. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.

	Pest	Product/1,000 L Water	Notes
INSECTS	Spruce budworm *(Choristoneura fumiferana)* **[Plate 1]**	Dragnet, 160 mL Foray 48 B, 1.6–2.4 L/ha Malathion 500 EC, 2.5 L Mimic 240 LV, 290 mL/ha Pounce, 45–90 mL Sevin 50 W, 1.1–2.2 kg	Larvae have a black head and brownish body with four light spots on the back of each segment. This pest is a widespread, important defoliator of balsam fir and spruce. Tiny, overwintering larvae begin to feed as buds break and continue feeding until late spring. Larvae can often be found feeding inside emerging shoots from suspiciously persistent bud caps. There is one generation per year. Apply Mimic to control early instar larvae; allow 3–7 days for larval mortality. A second application may be required. Apply general coverage spray for broad spectrum insecticides in mid-May to reduce larval populations.
	Spruce spider mite *(Oligonychus ununguis)* **[Plate 47]**	Cygon 480 E, 1.25 L Floramite SC, 625 mL horticultural oil, 20 L insecticidal soap, see label Kanemite 15 SC, 0.42–0.92 L Lagon 480, 1.25 L Landscape Oil, 10–15 L Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375–500 mL Vendex 50 W, 0.5–1.0 kg	Overwintered eggs hatch in early May, when *Amelanchier laevis* and *Magnolia x soulangiana* are in full bloom. Mites prefer older needles as feeding sites. To monitor for mites use a hand lens to check the undersides of twigs and needles for tiny reddish eggs or brown mites with black backs. Shake a branch over a white sheet of paper and look for crawling specks. Apply miticides when mites first appear. Kanemite is effective against motile life stages but may also reduce egg viability. Use horticultural oil as a dormant treatment in early spring to target eggs and newly hatched nymphs. DO NOT USE horticultural oil (including Landscape Oil) on white pine. Landscape Oil can be used when plants are dormant or in summer when leaves are fully expanded and hardened off. See product label. Permanent discolouration of foliage will occur to blue cultivars of both *Juniperus* and *Picea*. To prevent foliar discolouration on blue Colorado spruce, use only wettable powders and avoid horticultural oil. If populations are still significant, make two applications of other miticides at 10-day intervals when mites exist in spring. Many predatory mites co-exist with pest mite populations. To conserve predatory mites, try miticides that are softer on these beneficials, such as Vendex and Floramite.
	Tarnished plant bug *(Lygus lineolaris)* **[Plate 86]**	Ripcord 400 EC, 172 mL/ha	These are small, yellowish-brown insects with a five-sided "shield" appearance to the wings. Tarnished plant bugs feed by inserting their mouthparts inside leaf tissue and sucking out the contents, leaving the lower and upper epidermis behind. The resulting injury appears as small, clear "windows" on leaf tissue of broad-leaved plants. On conifers, feeding often causes terminal growth to yellow and become distorted and bushy. Treat in spring and early summer to manage populations of this insect.
DISEASES	Botrytis	Rovral 50 WP, 1.2–2 kg/ha	During very humid conditions (e.g., storage), a fuzzy grey growth may develop on succulent plant parts. Treat twigs and buds in spring before leaves develop. Treat conifer seedlings at the onset of botrytis. Remove all fading and diseased plant parts promptly, especially when wet weather is predicted. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Damping off, root rot and stem rot *(Phytophthora, Pythium)*	Subdue MAXX, 1.2 L/ha (drench)	Stem rot and root rot cause rapid dieback and mortality and are often characterized by reddish-brown discolouration of the cambium. Subdue MAXX can be used as a drench or a pre-incorporated treatment for media to help protect conifer seedlings and transplants from *Pythium* and *Phytophthora*. Subdue MAXX can be used on conifer seedbeds, plugs and 2-0 transplants only. See product label.
	Needlecast (various fungi)	Copper Spray, 4.0 kg Daconil 2787 F, 2.5 L	This is principally a nursery disease. It is caused by several fungi with 2-year life cycles. Symptoms develop early in the second season. Infected needles turn brown and drop. Badly infected plants have only current season needles. Spray after new growth begins and again 10 days later.

ACER — maple

	Pest	Product/1,000 L water	Notes
INSECTS	Aphid (various)	insecticidal soap, see label Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375 mL *Thiodan 4 EC, 1.25–1.75 L Tristar 70 WSP, 3 solupaks Trounce, 50 L	Treat when aphids first appear and repeat as required. Check leaves for honeydew and sooty mould. Aphids have many natural predators (e.g., ladybugs, hover flies, lacewings) so monitor for beneficial insects before making pesticide applications. Orthene may damage sugar maple leaves. * *Thiodan is toxic to fish*
	Cottony maple scale *(Pulvinaria innumerabilis)* **[Plate 2]**	horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20-30 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2.0 L Sevin 50 W, 2–3 kg	The mature female scale with white egg sac resembles a partially popped corn kernel. This scale infests maple, linden, elm, beech, oak and other trees and shrubs. It is found only on twigs. Use horticultural oil as early-spring dormant treatment. Do not use horticultural oil on sugar or Japanese maples. Nymphs are active in late June/early July, about when *Philadelphus* and *Tilia cordata* are in bloom. Direct insecticidal spray to the lower leaf surface. Repeat application 10 days later. Do not use Malathion on Crimson King maple. Orthene may damage sugar maple leaves.
	Forest tent caterpillar *(Malacosoma disstria)* **[Plate 3]**	Dipel, 0.5–1.0 L/ha Dragnet, 230 mL Foray, 1.0–1.6 L/ha Orthene 75 SP, 1.0 kg Pounce, 90 mL/ha Pyrate 480 EC, 500 mL Sevin 50 W, 2–3 kg Thuricide, 1.5–2.0 L	Forest tent caterpillar larvae are hairy with a series of keyhole-shaped white spots along their backs. Larvae are present early in the season. Larvae feed in colonies. Forest tent caterpillar larvae do not not form a tent on their host. Larvae may completely defoliate broadleaf trees, particularly poplars. Treat foliage mid-to-late May to reduce populations of larvae. Orthene may damage sugar maple leaves.
	Greenstriped mapleworm *(Dryocampa rubicunda)*	Sevin 50 W, 2.0–3.0 kg	Larvae have a cherry-red head and yellowish body with seven dark lines running its entire length. Preferred hosts are maple, oak and box elder. Insecticidal applications are usually not required. Eggs hatch over an extended period. If necessary, spray insecticides when larvae are present (from mid-June to late July).
	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown, fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).

INSECTS

Pest	Product/1,000 L water	Notes
Leafhopper (several species) **[Plate 41]**	Imidan 50 WP, 1.25 kg Sevin 50 W, 2.0 kg Sevin T&O, 2.3–3.5 L Tristar 70 WSP, 5 solupaks	Leafhoppers are tiny, yellowish-green to pale coloured insects that jump quickly when disturbed. Wingless nymphs will often "side step" quickly to hide from potential predators. Leafhoppers have piercing-sucking mouthparts that cause yellowish flecks on the leaf surface. Check regularly for infestation of nursery crops when neighbouring farms are cutting alfalfa or hay. Hang yellow sticky traps in the canopy to monitor for leafhoppers. Check by disturbing plants or looking at the leaf bottoms for leafhopper nymphs or molted skins. Injury appears as leaf distortion with blackened leaf margins. Older leaves will appear bronze coloured or stippled. Treat as required.
Lecanium or European fruit lecanium *(Lecanium corni)* **[Plate 4]**	horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20–30 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2.0 L Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 kg Trounce, 50 L	When adults are mature in late spring/summer they appear as a large, reddish-brown, spherical scale usually found on the underside of twigs. This scale infests many deciduous trees and shrubs. Use horticultural oil as early-spring dormant treatment to reduce populations of overwintering nymphs. Spray insecticides when the *Sambucus canadensis* begins blooming, to suppress crawlers. Do not use Malathion on Crimson King maple. Orthene may damage sugar maple leaves.
Maple bladder gall mite *(Vasates quadripedes)* Maple spindle gall mite *(Vasates aceriscrumena)* Crimson erineum mite *(Eriophyes regulus)*	horticultural oil, 20 L Malathion 500 EC, 2.5 L	Maple bladder gall mite causes globular, wart-like galls on the upper surface of silver and red maple leaves. Heavy infestations may completely deform leaves but seldom injure trees seriously. Maple spindle gall mite produces 5 mm long, slender fusiform galls on the upper surface of sugar and silver maple leaves. There are several generations per year. Crimson erineum mite causes granular red, velvety patches on both sides of sugar, silver and red maple leaves. Use horticultural oil as an early-spring dormant treatment. Do not use oil on sugar and Japanese maples. Apply Malathion in spring when temperature is 2°C or higher. Do not use Malathion on Crimson King maple.
Maple petiole borer *(Caulocampis acericaulis)*		The larvae bore inside leaf stems (petioles), causing petioles to turn black, shrivel and break near the blade causing leaf drop. Collecting and destroying fallen leaves will not reduce the population of this pest. Larvae remain in petioles that are still attached to the tree, where they complete their lifecycle. The adult is a tiny, amber-coloured sawfly that emerges as leaves are starting to emerge. Management with insecticides is usually not necessary.
Maple spider mite *(Oligonychus aceris)*	horticultural oil, 20 L	These tiny mites look very similar to spruce spider mite: brown bodies and legs with black backs. Mites overwinter as reddish-brown eggs close to bud scars on previous year's growth. Eggs hatch in spring, and mite numbers can build up by early summer. Mites feed on undersides of leaves, causing stippling and bronzing. Maple spider mites are most common on silver-red hybrids.
Maple trumpet skeletonizer *(Epinotia aceriella)* **[Plate 5]**	Sevin 50 W, 2.0–3.0 kg	This pest is normally a minor problem. It attacks sugar, red and silver maples. It spins a long trumpet-like tube of silk and frass on the underside of a leaf, which folds around it. The maple trumpet skeletonizer feeds from within this tube, skeletonizing the part of the leaf covered by the web. This causes the leaf to crumple. This pest may attack hawthorn and beech. Larvae exist from late July to September. Where necessary, apply control to bottom leaf surfaces from mid-July to mid-August.

ACER — maple *continued*

	Pest	Product/1,000 L water	Notes
INSECTS	Sugar maple borer *(Glycobius speciosus)*		This borer is usually a landscape problem, especially on stressed trees. It is a robust, black, longhorned beetle with five yellow bands on the wing covers. The fleshy white larva cuts deep channels in the wood. Cracked, swollen areas resembling cankers indicate infestation. The borer has a 2-year life cycle. Females cut a slit into the bark and lay eggs in late July and into August. Keep trees healthy in order to help them withstand infestations.
	Western flower thrips *(Frankliniella occidentalis)*	Success 480 SC, 50 mL	Western flower thrips will feed from inside terminal vegetative buds and flower buds. They have piercing, sucking mouthparts that suck out plant juices of immature leaves and flowers, resulting in major distortion and colour flecking when flowers and foliage do emerge. Western flower thrips can feed openly on new leaves or within the tissue of the bud. Injury may be confused with that of leafhoppers. Do not make more than three applications of Success 480 SC per year.
	Whitemarked tussock moth *(Orgyia leucostigma)*	Dragnet, 160 mL Mimic 240 LV, 290 mL/ha	The caterpillars are large (up to 3 cm long), with a multicoloured body marked by two tufts of black hairs behind the head and white hairs along the sides of the abdomen. Caterpillars are found throughout the growing season on many species of deciduous and evergreen trees. Apply Mimic to control early instar larvae; allow 3–7 days for larval mortality. A second application of Mimic may be required.
DISEASES	Anthracnose *(Gloeosporium apocrytum)*	Banner MAXX, 280 mL	Leaves are infected as they emerge in the spring. This disease causes irregular brown lesions, often in between veins. Leaves may be distorted. Collect and destroy fallen leaves in autumn, as they are a source of inoculum the following spring. Often, the second flush of growth will cover up this disease. Where disease pressure is high, protect newly emerging leaves with fungicides before leaf wetness periods.
	Leaf scorch **[Plate 73]**		Physiological leaf scorch is common symptom of desiccation on broadleaf decidous urban or roadside trees during hot, dry summers. Look for brown, dry leaf margins and areas in between leaf veins.
	Tar spot *(Rhytisma acerinum)* **[Plate 6]**		Emerged leaves are infected in spring during cool, wet weather. This disease causes irregular black tar-like spots on Norway and sugar maple by late summer. The tar spot fungus overwinters on fallen leaves. Collect fallen leaves in late summer and autumn and destroy. Removing fallen leaves from all infected neighbourhood trees may help reduce disease incidence the following year.
	Verticillium wilt *(Verticillium dahliae)* **[Plate 7]**		Infection causes the sapwood to darken into a greenish-black. This disease is often followed by frost cracks and associated cankers. See Table 4–18, *Woody Plants Resistant to Verticillium Wilt*, and Table 4–19, *Woody Plants Susceptible to Verticillium Wilt*, on page 86. Prune wilted branches back to healthy wood. Thin the remainder of the crown. Fertilize and water to promote vigour, especially root growth.

AESCULUS — horsechestnut

	Pest	Product/1,000 L water	Notes
DISEASES	Anthracnose *(Glomerella cingulata)*	Daconil 2787 F, 2.5 L	Protect leaves with fungicides during cool, wet springs. Encourage good air circulation through the canopy. Do not crowd plants.
	Leaf scorch (physiological)		Physiological leaf scorch is a common symptom of desiccation on broadleaf deciduous urban or roadside trees during hot, dry summers. Look for brown, dry leaf margins and areas in between leaf veins.
	Leaf blotch *(Guignardia aesculi)* *(Botryosphaeria aesculi)* **[Plate 8]**	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg	Symptoms include large, blotchy, reddish-brown lesions surrounded by a yellow halo. Lesions appear on leaves by mid-summer. Leaves often curl and distort. A tree may show symptoms of leaf blotch, scorch and anthracnose. Protect leaves with fungicides during cool, wet springs. Encourage good air circulation through the canopy. Do not crowd plants.

AMELANCHIER — serviceberry

	Pest	Product/1,000 L water	Notes
INSECTS	Western flower thrips *(Frankliniella occidentalis)*	Success 480 SC, 50 mL	Western flower thrips will feed from inside terminal vegetative buds and flower buds. They have piercing, sucking mouthparts that suck out plant juices of immature leaves and flowers, resulting in major distortion and colour flecking when flowers and foliage do emerge. Western flower thrips can feed openly on new leaves or within the tissue of the bud. Injury may be confused with that of leafhoppers. Do not make more than three applications of Success 480 SC per year.
DISEASES	Cedar-apple rust *(Gymnosporangium* sp.*)*	Nova 40 W, 250–340 g	Spores from *Juniperus* hosts can infect rosaceous plants *(Malus, Crataegus, Amelanchier,* etc.). Treat when sporulation begins on alternate host *(Juniperus),* in mid-spring. Repeat fungicidal application every 10–14 days if needed. Rotate Nova with registered fungicides of other chemical families to avoid resistance.
	Powdery mildew	Nova 40 W, 113 g	Fungal infection appears as white, powdery growth on the upper leaf surface. Use Nova 40 W at the first sign of powdery mildew to manage this disease on Saskatoonberry. Use Nova 40 W no more than three times per season.

BETULA — birch

	Pest	Product/1,000 L water	Notes
INSECTS	Aphid *(Calaphis betulaecolens)* *(Euceraphis punctipennis)* *(Hamamelistes spinosus)*	Cygon 480 E, 625 mL insecticidal soap, see label Tristar 70 WSP, 3 solupaks Trounce, 50 L	*Calaphis betulaecolens*, a large [illegible] aphid, feeds only on birch. *Euceraphis punctipennis*, a blac[illegible] and green aphid, leaves a cottony-white wax on birch and alder. *Hamamelistes spinosus* feeds on birch and on *Hamamelis* (witch hazel). Feeding nymphs cause corrugated swellings between veins on leaves. Treat when adults first appear; repeat as required. Check underside of leaves for honeydew and sooty mould. Many natural predators feed on aphids (e.g., ladybugs, hoverflies, lacewings).
	Birch leafminer (*Fenusa pusilla* and many other species) **[Plate 9]**	Cygon 480 E, 500 mL DZN 600 EW, 830 mL Imidan 50 WP, 1.25 kg Lagon 480, 500 mL Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Sevin 50 W, 2–3 kg	Larval mines look like a brown blotch sometimes covering half or more of each leaf. Foliage of heavily infested trees looks scorched. There are two generations a year; the second flush of growth is also attacked. The adult is a small black sawfly that emerges from the soil when first leaves are half grown. First mines appear when *Spiraea x vanhouttei* blooms. When mines appear, use any listed control in mid-May and about 6 weeks later (when the second flush of leaves is attacked).
	Birch skeletonizer *(Bucculatrix canadensisella)*	Sevin 50 W, 2.0–3.0 kg	This pest is generally not a significant problem. Small yellowish-green larvae attack birches and some alders. Larvae feed on the bottom of leaves from mid- to late summer. Collect and destroy fallen leaves to remove overwintering pupae. Thoroughly spray underside of leaves about mid-August.
	Bronze birch borer *(Agrilus anxius)* **[Plates 10 and 11]**	Pyrate 480 EC, 500 mL	This beetle attacks injured and weakened birch trees. The elongated white larvae make long, winding tunnels just under the bark. Tunnels show up as spiral ridges around the branches and trunk. Larvae develop over 2 years and emerge as adults from June to August, through a D-shaped hole. The adult is a slender, olive-bronze beetle. Remove and destroy weakened and dying branches before mid-May. Good tree health reduces infestation risks. Birch roots do not compete well with lawn grasses. Deeply water the root zone several times during the growing season. Control birch leafminers to reduce stress. Direct spray at trunk and branches. Chemical control is very difficult.
	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).

BUXUS — boxwood

	Pest	Product/1,000 L Water	Notes
INSECTS	Boxwood leafminers *(Monarthropalpus buxi, M. flavus)*	Cygon 480 E, 1 L Diazinon 500 EC, 1 L DZN 600 EW, 830 mL Lagon 480, 1 L Malathion 50, 1.5 L Sevin 50 W, 2.0–3.0 kg	Larvae overwinter in leaves and pupate in spring. The adult is a gnat-like fly that lays eggs into new foliage. Second-generation larvae mine new leaves in spring and throughout the summer. Treat new foliage when the first mines begin to appear.
	Boxwood psyllid *(Psylla buxi)*	insecticidal soap, see label Sevin 50W, 2.0–3.0 kg	Orange eggs overwinter next to buds. Overwintering eggs hatch as buds begin to break in spring. Young nymphs are light green and develop a white, woolly protective mass as they get older. Nymphs feed on developing leaves. Leaves become cupped, enclosing the nymphs. Treat young psyllids after egg hatch, as leaves are emerging.
DISEASES	Boxwood blight and canker *(Volutella buxi)* **[Plate 12]**		Black cankers appear on stems and leaves of *Buxus*. Cankers may be accompanied by orange-white pustules in high humidity (e.g., propagation). This blight can be a problem in propagation areas and sometimes in older plants. Always inspect cuttings and rooting beds for signs of canker. Higher temperatures and well-drained media will accelerate rooting and decrease incidence of this disease in propagation (e.g., summer propagation). Remove and destroy infected leaves and stems in established plants.

CARAGANA — pea shrub

	Pest	Product/1,000 L Water	Notes
INSECTS	Leafhopper (several species) **[Plate 41]**	Imidan 50 WP, 1.25 kg Sevin 50 W, 2.0 kg Sevin T&O, 2.3–3.5 L Tristar 70 WSP, 5 solupaks	Leafhoppers are tiny, yellowish-green to pale coloured insects that jump quickly when disturbed. Wingless nymphs will often "side step" quickly to hide from potential predators. Leafhoppers have piercing-sucking mouthparts that cause yellowish flecks on the leaf surface. Check regularly for infestation of nursery crops when neighbouring farms are cutting alfalfa or hay. Hang yellow sticky traps in the canopy to monitor for leafhoppers. Check by disturbing plants or looking at the leaf bottoms for leafhopper nymphs or molted skins. Treat as required.
	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These tiny mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

CARYA — hickory

	Pest	Product/1,000 L Water	Notes
INSECTS	Hickory gall adelgid *(Phylloxera caryaecaulis)*	Malathion 500 EC, 1.25 L Pyrate 480 EC, 375 mL Tristar 70 WSP, 3 solupaks	This pest produces nearly-round galls on hickory twigs and leaf stems. Galls are about 16 mm in diameter. Girdled twigs die and break at the location of a gall. Overwintering eggs hatch as buds break. Apply insecticides at that time. Treatment is ineffective once galls appear. Infestations will not kill the tree.
	Walnut caterpillar *(Datana integerrima)*	Malathion 500 EC, 2.5 L Sevin 50 W, 1.0–1.5 kg	Larvae are black with long grey hairs. This caterpillar feeds on walnut and hickory. Caterpillar colonies descend tree trunks and molt, leaving a conspicuous clump of grey cast skins on the trunk. Adult moths lay eggs in early July, and larvae feed until the end of August. Spray when larvae first appear, usually in July. Feeding will continue into August and September. Spray or remove larvae clustering on trunk.

CHAENOMELES — quince

	Pest	Product/1,000 L Water	Notes
INSECTS	Fire blight *(Erwinia amylovora)* **[Plate 42]**	Serenade Max, 2.5–6 kg/ha	Fire blight infects succulent vegetative growth. Dead, dry leaves persist on infected branches. Spray bactericidal products at early bloom, full bloom and petal fall where weather is warm and humid and fire blight is a recurring problem. Avoid excessive pruning and nitrogen fertilization in spring. During dormancy, prune out infected branches about 30 cm below the cankered area when the tree is dry.

CLEMATIS — clematis

	Pest	Product/1,000 L Water	Notes
INSECTS	Two-spotted spider mite *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)
	Western flower thrips *(Frankliniella occidentalis)*	Success 480 SC, 50 mL	Western flower thrips will feed from inside terminal vegetative buds and flower buds. They have piercing, sucking mouthparts that suck out plant juices of immature leaves and flowers, resulting in major distortion and colour flecking when flowers and foliage do emerge. Western flower thrips can feed openly on new leaves or within the tissue of the bud. Injury may be confused with that of leafhoppers. Do not make more than three applications of Success 480 SC per year.

CORNUS — dogwood

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various)	insecticidal soap, see label Trounce, 50 L	Aphids appear as new growth emerges in the spring. Repeated applications of insecticidal soap will be required to reduce aphid populations.
	June beetle *(Phyllophaga* sp.*)* European chafer *(Rhizotrogus majalis)* **[Plate 17]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L	These beetle larvae are referred to as "white grubs." The larvae chew fibrous roots and girdle underground stems of many woody ornamentals (including *Cornus* sp.). Cultivate infested fields before planting to expose grubs to natural predators. Sevin T&O is registered as a foliar spray for adults. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
DISEASES	Anthracnose *(Glomerella cingulata)* *(Colletotrichum gloeosporioides)*	Banner MAXX, 280 mL Nova 40W, 340 g	Leaves develop brown lesions in spring, often between veins. Leaves may become deformed and fall off. This fungus infects leaves as they are emerging in the spring. Where disease pressure is high, protect newly emerging leaves with fungicides before leaf wetness periods in spring.
	Leaf spot **[Plate 18]**	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Nova 40W, 340 g	This disease is caused by several different fungi. Avoid overhead irrigation late in the day or at night. Do not crowd plants. Maintain adequate sunlight and good air circulation. Protect new leaves with fungicides at the first sign of disease.
	Powdery mildew	MilStop, 2.8–6.5 kg	This disease appears as a white, powdery fungal growth on the tops of leaves. MilStop will help suppress powdery mildew when applied preventively.
	Twig blight		This disease is caused by several different fungi. Cankers appear at the base of dead twigs. Prune infected twigs and branches back to healthy wood. Improve cultural conditions by watering during dry conditions. Do not crowd plants. Maintain adequate sunlight and good air circulation.

CORYLUS — corkscrew hazel, filbert

	Pest	Product/1,000 L Water	Notes
INSECTS	Eastern filbert blight *(Anisogramma anomala)*	Copper Spray, 3 kg/ha	Filbert blight causes branch dieback and small, crescent-shaped, black cankers on killed stems. Prune out cankered branches when the plant is dormant and dry. Protect new growth with fungicides from bud swell to leaf emergence.

COTONEASTER — cotoneaster

	Pest	Product/1,000 L Water	Notes
INSECTS	Phytophthora root rot **[Plate 19]**		Infected roots become water-soaked and turn brown. Infected stems and leaves turn brown and die. Diseased leaves often persist on stems. Quite often the cambium turns from green to reddish-brown. This disease is often associated with overwatering or low aeration porosity of media.

CRATAEGUS — hawthorn

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphids (various)	Endeavor, 100–200 g Tristar 70 WSP, 3 solupaks Trounce, 50 L	Aphids are soft-bodied insects that suck plant sap. They can be found on soft, succulent plant tissue. Feeding causes distorted growth, honeydew and sooty mould. Apply insecticides to reduce populations. Do not make more than three applications of Endeavor per year. Do not apply more than 3 kg of Endeavor per hectare per year.
	Eastern tent caterpillar *(Malacosoma americanum)* **[Plate 40]**	Diazinon 500 EC, 925 mL Dipel 132 ES, 0.5–1.0 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Malathion 500 EC, 2.5 L Orthene 75 WP, 1 kg Pounce, 90 mL Sevin 50 W, 2.0–3.0 kg Success 480 SC, 25 mL Thuricide, 1.5–2.0 L	This caterpillar has one white stripe down its back. Colonies feed early in the season. Silken tents appear in the forks of branches, mainly of apple, cherry and hawthorn trees. Prune and destroy overwintering egg masses. These are silver in colour, about 1–2 cm long in a raised band circling a twig. They hatch when buds break in spring. Treat then or at the first sign of webs. In light infestations, remove and destroy the tents (which contain larvae).
	Hawthorn leafminer *(Profensua canadensis)*	Malathion 500 EC, 2.5 L Sevin 50 W, 2.0–3.0 kg	This leafminer forms a blotch mine covering half or more of each leaf. Foliage of heavily infested trees looks scorched. The adult is a small, black sawfly that emerges from the soil as the first leaves start to emerge and blossoms begin to open. Adults are active as the leaves begin to unfold. Treat foliage as it emerges in spring to reduce larval populations.
	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

	Pest	Product/1,000 L Water	Notes
INSECTS	Western flower thrips *(Frankliniella occidentalis)*	Success 480 SC, 50 mL	Western flower thrips will feed from inside terminal vegetative buds and flower buds. They have piercing, sucking mouthparts that suck out plant juices of immature leaves and flowers, resulting in major distortion and colour flecking when flowers and foliage do emerge. Western flower thrips can feed openly on new leaves or within the tissue of the bud. Injury may be confused with that of leafhoppers. Do not make more than three applications of Success 480 SC per year.
DISEASES	Fire blight *(Erwinia amylovora)* **[Plate 42]**	Copper Spray, 1.25 kg Serenade Max, 2.5–6 kg/ha	Fire blight affects succulent vegetative growth. Dead, dry leaves persist on infected branches. Spray bactericidal products at early bloom, full bloom and petal fall where weather is warm and humid and fire blight is a recurring problem. Avoid excessive pruning and nitrogen fertilization in spring. During dormancy, prune out infected branches about 30 cm below the cankered area when the tree is dry.
	Hawthorn rust *(Gymnosporangium globosum)* **[Plate 15]** Quince rust *(G. clavipes)* **[Plate 16]**	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Nova 40 W, 340 g	Symptoms appear as orange spots on leaf surfaces in late spring. In the case of *G. globosum*, finger-like structures appear on leaf undersides by mid- to late summer. Infections of *G. clavipes* also appear on fruit and stems. Apply fungicide before bloom when alternate hosts (juniper) are sporulating. Remove alternate juniper hosts and/or separate alternate hosts as far away as possible from Rosaceous hosts (*Malus, Crataegus* etc.).
	Leaf blight *(Diplocarpon* sp.*)*	Dithane DG, M-45, 80 WP, 2.75–3.5 kg Manzate DF, 2.75–3.5 kg	Symptoms appear as small brown spots on leaves in mid-summer. Spray fungicides in spring to help protect leaves as they emerge. Do not crowd plants. Maintain adequate sunlight and good air circulation. Avoid summer pruning, which encourages susceptible soft growth.
	Leaf spot *(Fabraea* sp.*)*	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg	Leaf spot appears as slightly depressed, angular, reddish-brown spots that join together. By mid-summer, dead areas have dark raised bumps (fruiting structures). Collect and destroy fallen leaves. Spray protectant fungicides as flower buds open. Repeat applications if spots develop. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Powdery mildew	Compass 50 WG, 140–210 g	This fungus appears as a white, powdery growth on the tops of leaves. Apply fungicides at the first sign of disease to reduce disease spread.

EUONYMUS — euonymus

	Pest	Product/1,000 L Water	Notes
INSECTS	Black vine weevil *(Otiorhynchus sulcatus)* **[Plates 80 and 81]**	Nemasys G, BGreen, see label *Thiodan 4 EC, 1.75 L	Larvae are small, white, legless grubs that eat fibrous roots or strip bark off larger roots. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. Larvae control is difficult. Adults are black snout beetles that hide in soil litter during the day and cut crescent-shaped notches in needle margins at night. They also attack arborvitae, hemlock, azaleas, yews and rhododendrons. In container production, they are also significant pests of several hosts, including herbaceous perennials. The beetles have fused wing covers and cannot fly. To control adults, treat foliage, trunk bark and branches during the last week of June and in early July. Spray in the evening, as adult activity increeses about an hour after sunset. Do not use Thiodan on Anderson yew. To test treatment safety, treat some conifer seedlings, especially pine, before treating a larger area. Entomopathogenic nematodes (e.g., *Heterohabditis* sp.) are available to help suppress populations of larvae. Nematodes work very well in infested containers but with less success in the field. Nematodes can be applied in late summer/early autumn and in mid-spring to suppress larval populations. See product label for complete directions. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. ** Thiodan is toxic to fish.*
	Euonymus scale *(Unaspis euonymi)* **[Plates 20 and 21]**	Cygon 480 E, 2 L horticultural oil, 20 L Lagon 480 E, 2 L Landscape Oil, see label Orthene 75 SP, 1.0 kg	This greyish, pear-shaped scale also affects bittersweet *(Celastrus)* and *Pachysandra*. It produces two generations a year; the second generation appears about 6 weeks after the first. Examine plants during the dormant season, prune out highly infested regions and use dormant oil. Apply insecticides as nymphs emerge. *Catalpa speciosa* are beginning to bloom at this time; *Kolkwitzia* and *Philadelphus* are also blooming. Repeat treatment after 7 days. Landscape Oil can be used when plants are dormant or in the summer when foliage is fully expanded and hardened off. See product label.
	Euonymus webworm *(Yponomeuta cagnagella)* **[Plate 22]**	Dragnet, 230 mL Pounce, 90 mL	The larva is a pale yellow caterpillar with black spots along each side. Larvae feed on leaves in localized, webbed colonies. Severe defoliation can occur during June. Monitor deciduous euonymus for webbed colonies in May and June. Where possible, prune colonies out and destroy.
	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

	Pest	Product/1,000 L Water	Notes
DISEASES	Anthracnose *(Glomerellacingulata, Colletotrichum gloeosporioides)* **[Plate 23]**	Daconil 2787, 2.5 L Daconil Ultrex, 1.5 kg	Symptoms appear as a leaf spot and stem blight that is most prevalent on container-grown euonymus. Leaf spots are small, circular and dark brown with light brown centres about 0.5 to 3 mm in diameter. Infected foliage often drops (although extreme temperatures and humidity will also cause leaf drop). Stem lesions appear as brown-to-grey, raised, oval, scabby cankers that lead to dieback of stem and leaves above the canker. Variegated cultivars of *Euonymus fortunei* are the most susceptible to anthracnose. This fungus is a weak pathogen and infection is usually facilitated by mechanical wounds (e.g., pruning) or low temperature injury and freezing damage. This fungus infects and grows best during high temperatures and high humidity during leaf wetness periods (June, July). To protect new growth, spray at bud break and through leaf emergence, especially during high temperatures and humidity. Maintain good air circulation. To limit leaf wetness periods, irrigate susceptible cultivars during mid-morning only. Prune out dead and dying twigs, especially in fall.
	Crown gall *(Agrobacterium tumefaciens)* **[Plate 24]**	Dygall, 160 g/50 L	This gall appears as large abnormal growths on stems and roots. Susceptible plants must be treated before disease exposure or final field placement. Wounding (e.g., pruning) and damaging plants facilitate infection of this pathogen. Remove and destroy infected plants. This is a soil-borne bacteria.

FAGUS — beech

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various) Beech blight aphid *(Fagiphagus imbricator, Grylloprociphilus imbricator)* Woolly beech leaf aphid *(Phyllaphis fagi)*	insecticidal soap, see label Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375 mL *Thiodan 4 EC, 1.25–1.75 L Tristar 70 WSP, 3 solupaks Trounce, 50 L	Conspicuous white, cottony threads cover beech blight aphid and woolly beech leaf aphid. Beech blight aphid appears on twigs and small branches. The woolly beech leaf aphid feeds on leaf undersides. While unsightly, it causes little tree damage unless very high populations exist. Treat when aphids first appear, and repeat as needed. Excessive fertilization or pruning can cause undesirable succulent growth levels that are attractive for these aphids. ** Thiodan is toxic to fish.*
	Cankerworm *(Alsophila pometaria)* *(Paleacrita vernata)* **[Plates 38 and 39]**	Dipel 132 ES, 1.6–2.4 L/ha Orthene 75 SP, 1.0 kg	Green and dark-grey inchworms (loopers, geometrids) can be found feeding on leaf undersides and edges in spring. Cankerworm can cause significant defoliation to deciduous trees. Treat with insecticides when larvae are small.
	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).

FORSYTHIA — forsythia

	Pest	Product/1,000 L Water	Notes
INSECTS	Bacterial blight *(Pseudomonas syringae)*	Clean Crop Copper Spray, 6.0 kg	Young shoots or leaves turn black between early spring and early summer, especially during wet, cool weather. Apply copper spray once in October and again in January. During blight conditions in April and May, apply 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals. Avoid overhead irrigation late in the day. Do not crowd plants. Maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth levels.

FRAXINUS — ash

	Pest	Product/1,000 L Water	Notes
INSECTS	Ash flower gall mite *(Eriophyes fraxiniflora)*	horticultural oil, 20 L Landscape Oil, 20–30 L Malathion 25 WP, 2.0 kg	This mite becomes active as male ash flower buds break in the spring. It feeds on the unfolding tissues, causing them to form irregular gall clusters of 12 mm diameter. Use horticultural oil as a dormant treatment. Mites become active as flower buds break in the spring. Use Malathion when first blossoms begin to emerge. Landscape Oil can be used when the plant is dormant or in the summer when leaves are fully expanded and hardened off. See product label.
	Ash-lilac borer *(Podosesia syringae)*	Pyrate 480 EC, 500 mL *Thiodan 4 EC, 1.25 L	Adults are dark brown, wasp-like moths, present from late May to late July (during *Syringa vulgaris* bloom). Larvae bore into trunks near the base. Lilac, mountain ash and privet are also hosts. Cut and destroy infested wood before May. Stressed trees are more susceptible to borers. Prevent wood and bark damage. Remove badly infested trees. Use pheromone traps to monitor adult activity. Treat trunk and large branches, especially around wounds, with insecticides when the *Syringa vulgaris* is in bloom. Repeat twice at 10-day intervals. Begin applications about 10 days after peak catch numbers. ** Thiodan is toxic to fish.*
	Ash plant bug *(Tropidosteptes amoenus)*	Dylox 420, 2.75–4.0 L Sevin T&O, 2.6 L	This bug feeds on *Fraxinus americana* and *F. pennsylvanica*. Young nymphs feed on leaf bottoms, causing leaf stippling. To monitor for plant bugs, tap a branch over a sheet of white paper or tapping tray. Treat with insecticides when nymphs appear.
	Emerald ash borer *(Agrilus planipennis)* **[Plate 25]**	Check with the OMAFRA Nursery Crops Specialist for registered pesticides.	This exotic insect was first found in Essex County, Ontario, in 2002. Larvae bore into the cambium, making serpentine tunnels just under the bark. Small (8–14 mm), metallic green, adult beetles emerge through tiny D-shaped holes in the bark from spring to summer. The larval tunnels in the cambium kill off sections of the tree, leading to dieback, epicormic branching at the base and tree mortality. This borer is most commonly found on *Fraxinus pennsylvanica*. This is a quarantined pest, regulated by the Canadian Food Inspection Agency.
	Fall webworm *(Hyphantria cunea)* **[Plate 26]**	Dipel, see product label Dragnet, 230 mL Dylox 2.75–4 L/ha Orthene 75 SP, 1.0 kg Pounce, 90 mL	Large webs appear in August over branch ends of ash, box-elder, flowering crab and many shade trees. The very hairy caterpillar is pale yellowish green. Chemical control is rarely needed. Remove webs and caterpillars by hand and destroy.

INSECTS

Pest	Product/1,000 L Water	Notes
Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).
Lecanium or European fruit lecanium *(Lecanium corni)* **[Plate 4]**	horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20–30 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2.0 L Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 kg Trounce, 50 L	When adults are mature in late spring/summer they appear as a large, reddish-brown, spherical scale usually found on the underside of twigs. This scale insect infests many deciduous trees and shrubs. Use horticultural oil as early-spring dormant treatment to reduce populations of overwintering nymphs. To suppress crawlers, spray insecticides when the *Sambucus canadensis* begins blooming. Do not use Malathion on Crimson King maple. Orthene may damage sugar maple leaves.
Leopard moth *(Zeuzera pyrina)* **[Plates 27 and 28]**		The larval stage bores into the branch tips and eventually into heartwood of trees (as larvae grow larger), weakening the tree and causing dieback and tree mortality. Look for bore holes in branch tips and large bore holes with sawdust at the base of the trunk. Larvae are large (up to 50 mm) and cream-coloured with black spots. Control is difficult once the borer has become established in a tree. Remove infested trees and destroy. Insert a piece of flexible wire in and upwards via the bore hole to destroy larvae. Leopard moths are rarely found in large numbers.
Oystershell scale *(Lepidosaphes ulmi)*	Diazinon 500 EC, 1.5 L insecticidal soap, see label Landscape Oil, see label Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2 L	This scale inset attacks over 125 forest, shade, fruit and ornamental tree species. In heavy infestations, greyish scales completely encrust twigs and stems. This can cause branch and tree mortality. Mature females are 3 mm long and rounded at the rear, resembling oyster shells. Eggs overwinter under dead female shells, rendering them completely resistant to pesticides applied in fall or early spring. Use insecticides when crawlers are present in late May. Apply again 10 days later, about the time *Spiraea x vanhouttei* is blooming. Ensure good coverage of trunk, branches and leaf bottoms. Landscape Oil can be used in the summer when leaves are fully expanded and hardened off. See product label.
Sycamore lacebug *(Corythucha ciliata)*	Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Sevin 50 W, 2–3 kg	Lacebugs are flat, rectangular insects, 4–6 mm long with broad, transparent, lacelike wing covers. Adults and nymphs feed on the underside of leaves. Leaves become pale and mottled, with white splotches. Lower leaf surfaces develop black and brownish dots. Heavily infested leaves may turn entirely brown and fall off. Most species have two generations a year. Lacebugs usually occur on a single host. Other trees commonly attacked include elm, hickory, linden, oak and walnut. Apply insecticides to leaf undersides when insects first appear.

FRAXINUS — ash *continued*

	Pest	Product/1,000 L water	Notes
DISEASES	Anthracnose *(Gloeosporium aridum)* **[Plate 30]**	Dithane DG, M-45, 80 WP, 2.75–3.5 kg Manzate 200 DF, 2.75–3.50 kg	Symptoms appear as leaf spots, marginal leaf browning and leaf deformation. Defoliation may occur in late spring and early summer. Apply treatments at 10–14-day intervals, beginning before bud burst and continuing while wet weather persists in spring. Collect and destroy fallen leaves. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Leaf spot *(Mycosphaerella sp.)*	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg	Brown spots with yellowish borders appear by late summer. Apply fungicides at bud break. Collect and destroy fallen leaves to help reduce disease pressure. Do not crowd plants. Maintain adequate sunlight and good air circulation.

GLEDITSIA — honeylocust

	Pest	Product/1,000 L Water	Notes
INSECTS	Cottony maple scale *(Pulvinaria innumerabilis)* **[Plate 2]**	horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20–30 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2.0 L Sevin 50 W, 2–3 kg	Mature female scale insects with white egg sacs resemble a partially popped corn kernel. This insect infests maple, linden, elm, beech, oak and other trees and shrubs. It is found only on twigs. Use horticultural oil as early-spring dormant treatment. Do not use horticultural oil on sugar or Japanese maples. Nymphs are active in late June/early July, about when *Philadelphus* and *Tilia cordata* bloom. Direct the insecticidal spray to the lower leaf surface. Repeat the application 10 days later. Do not use Malathion on Crimson King maple. Orthene may damage sugar maple leaves.
	Honeylocust plant bug *(Diaphnocoris chlorionis)* **[Plate 29]**	Dylox 420, 2.75–4.0 L insecticidal soap, see label	Plant bugs become active as new leaves begin to emerge. Plant bug feeding causes leaf yellowing, stippling, stunting and deforming early in the season. Shoot dieback may occur. To monitor for plant bugs, tap a branch over a sheet of paper or tapping tray or use a sweep net. Apply insecticides when nymphs are active and numerous.
	Honeylocust podgall midge *(Dasyneura gleditchiae)*		The adult is a small insect similar to a fruit fly. It lays eggs on new leaflets, and larvae feed on the inner surface. This causes a pod-like structure to appear. There are several generations a year. Chemical control is very difficult.
	Honeylocust spider mite *(Eotetranychus multidigituli)* **[Plate 29]**	Kelthane EC, 1.25–2.50 L Landscape Oil, 20–30 L Orthene 75 SP, 1.0 kg	Adults overwinter on bark. Mites are light orange and very difficult to see with the naked eye. Feeding causes stippling, bronzing and discoloured foliage. Heavy infestation may cause defoliation. Treat when mites appear and again in 10 days. Repeat the procedure as needed. Landscape Oil can be used in the summer when leaves are fully expanded and hardened off. See product label.
	Leafhopper *(Macropsis fumipennis)* **[Plate 29]**	Orthene 75 SP, 1.0 kg Pyrate 480 EC, 1.0 L Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 kg Tristar 70 WSP, 5 solupaks	Symptoms of leafhoppers include leaf spotting and stippling and blackening of leaf margins. Leafhoppers become active as new leaves begin to develop. Treat leaf bottoms when leafhoppers are active (about mid-June), and repeat as needed. To monitor leafhoppers, tap a branch over a sheet of paper or tapping tray or use a sweep net.
	Leafrollers (various)	Dipel, see product label	Leafrollers are caterpillars that feed while hidden in folded or rolled leaves. Fruit tree and redbanded leafrollers primarily affect fruit trees, but also attack many shade trees and ornamentals. Apply insecticide to foliage soon after leaves unfold in early June.

	Pest	Product/1,000 L Water	Notes
INSECTS	Lecanium or European fruit lecanium *(Lecanium corni)* **[Plate 4]**	horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20–30 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2.0 L Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 kg Trounce, 50 L	When adults are mature in late spring/summer, they appear as a large, reddish-brown, spherical scale usually found on the underside of twigs. This scale insect infests many deciduous trees and shrubs. Use horticultural oil as early-spring dormant treatment to reduce populations of overwintering nymphs. To suppress crawlers, spray insecticides when the *Sambucus canadensis* begins blooming.

HEDERA — ivy

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various)	insecticidal soap, see label	Aphids become numerous as new growth emerges in the spring. Repeated applications of insecticidal soap will help smother aphids.
	Two-spotted spider mite *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

HEMEROCALLIS — daylily

	Pest	Product/1,000 L Water	Notes
INSECTS	Daylily rust *(Puccinia hemerocallidis)*	Heritage EC, 282 g/ha (0.3 g/L)	Daylily rust appears as orange, raised pustules in late summer and autumn. Yellow zones often encircle the pustules and leaves may be killed, especially on very susceptible cultivars. Orange, dusty spores arise from the pustules and spread by wind and rain to infect other plant foliage. See OMAFRA Factsheet *Daylily Rust*, Order No. 04-089 at www.ontario.ca/crops. Heritage fungicide is for use on daylilies to prevent the infection of daylily rust whenever spores may be present (usually starting in September in Ontario). Apply every 14–28 days. Do not make more than two applications per season.
	Western flower thrips *(Frankliniella occidentalis)*	Success 480 SC, 50 mL	Western flower thrips will feed from inside terminal vegetative buds and flower buds. They have piercing, sucking mouthparts that suck out plant juices of immature leaves and flowers, resulting in major distortion and colour flecking when flowers and foliage do emerge. Western flower thrips can feed openly on new leaves or within the tissue of the bud. Injury may be confused with that of leafhoppers. Do not make more than three applications of Success 480 SC per year.

HEMEROCALLIS — daylily *continued*

	Pest	Product/1,000 L Water	Notes
DISEASES	Rhizoctonia stem blight *(Rhizoctonia* sp.*)*	Compass 50 WG, 3.8 g/100 L	Apply Compass as a drench at the time of propagation to help protect *Hemerocallis* from rhizoctonia stem blight.

HERBACEOUS PERENNIALS

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid	Endeavor, 100–200 g Tristar 70 WSP, 3 solupaks	Various species of aphids feed on herbaceous ornamentals. Aphids are small, soft-bodied insects that have piercing, sucking mouthparts to suck plant sap. Feeding causes distortion and stunting of foliage.
	Black vine weevil Taxus weevil *(Otiorhynchus sulcatus)* **[Plates 80 and 81]**	Nemasys G, BGreen, see label Sevin 50 W, 2.00–3.0 kg *Thiodan 4 EC, 1.25–1.75 L *Thionex 50 WP, 1.5 kg	Larvae are small, white, legless grubs that eat fibrous roots or strip bark off larger roots. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. Larvae control is difficult. Adults are black snout beetles that hide in soil litter during the day and cut crescent-shaped notches in needle margins at night. They also attack arborvitae, euonymus, hemlock, azaleas, yew and rhododendrons. They are a significant pest in container production. The beetles have fused wing covers and cannot fly. To control adults, treat foliage, trunk bark and branches during the last week of June and in early July. Spray in the evening, as adult activity increases about an hour after sunset. Do not use Thiodan on Anderson yew. To test treatment safety, treat some conifer seedlings, especially pine, before treating a larger area. Entomopathogenic nematodes (e.g., *Heterohabditis* sp.) are available to help suppress populations of larvae. Nematodes work very well in infested containers but with less success in the field. Nematodes can be applied in late summer/early autumn and in mid-spring to suppress larval populations. See product label for complete directions. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. ** Thiodan and Thionex are toxic to fish.*
	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

	Pest	Product/1,000 L Water	Notes
INSECTS	Western flower thrips *(Frankliniella occidentalis)*	Success 480 SC, 50 mL	Western flower thrips will feed from inside terminal vegetative buds and flower buds. They have piercing, sucking mouthparts that suck out plant juices of immature leaves and flowers, resulting in major distortion and colour flecking when flowers and foliage do emerge. Western flower thrips can feed openly on new leaves or within the tissue of the bud. Injury may be confused with that of leafhoppers. Do not make more than three applications of Success 480 SC per year.
DISEASES	Botrytis flower blight *(Botrytis cinerea)*	Captan 50 W, 2 kg Daconil 2787, 2.5 L Daconil Ultrex, 1.5 kg Rhapsody, 10–20 L Rovral WP, 1 kg	Botrytis blight appears as a grey, fuzzy mould on succulent plant tissues (e.g., flowers). Apply fungicides when disease first appears, and repeat at 7–10-day intervals.
	Crown and root rots	Rootshield *(Trichoderma harzianum)* Senator 70 WP, 650–850 g	Various fungi cause root and crown rots on ornamentals. Many are a function of improper environmental conditions and media properties. Apply Rootshield as a preventive drench after cuttings are stuck, seeds are sown or young plants are transplanted. Rootshield can also be applied as pre-mix granules with media. Rootshield helps suppress soil-borne pathogens such as *Pythium, Rhizoctonia* and *Fusarium*. It is registered for greenhouse ornamentals only.
	Damping-off, bulb rots	Captan 50W, 6–15 kg Captan 80 WDG, 3.8–9.4 kg	Use Captan as a bulb dip before storage of bulbs. Allow the fungicide to dry on bulbs prior to storage.
	Damping-off, root and stem diseases *(Pythium, Phytophthora)*	Subdue MAXX, see product label	*Pythium* and *Phytophthora* cause stem and root rots of many ornamentals, especially under saturated soil conditions where media does not offer enough drainage (or aeration). Subdue MAXX can be used on a specific group of ornamentals (see product label). Apply Subdue MAXX to the media prior to potting or as a drench after seeding or transplanting. Irrigate within 1–2 days to ensure the product reaches the root zone. To avoid fungicide resistance, rotate Subdue MAXX with other families/groups of fungicides.
	Leaf spot (various fungi)	Folpan 50 WP, 2 kg Rhapsody, 10–20 L	Look for distinct, brown spots on herbaceous perennials. Protect new growth with fungicides at the first sign of disease. Apply Rhapsody prior to or at early stages of disease and repeat every 7 days.
	Powdery mildew	Folpan 50 WP, 2 kg MilStop, 0.28–0.56 kg/1,000 m^2 Rhapsody, 10–20 L	Powdery mildew appears as a white, powdery fungal growth on the tops of leaves. Early signs include small, circular whitish colonies. MilStop and Rhapsody can be used for the suppression of powdery mildew. Start applications at the first sign of disease.
	Rhizoctonia root and crown rot	Compass 50 WG, 3.8 g/100 L Rovral WP, 400 g Senator 70 WP, 650–850 g	Rhizoctonia causes crown and root rot of several ornamentals. Apply Compass as a drench at the time of propagation. Compass may cause injury to petunia, violet and New Guinea impatiens.

HYDRANGEA — hydrangea

	Pest	Product/1,000 L Water	Notes
DISEASES	Botrytis blight *(Botrytis cinerea)*	Botran 75 W, 1.75 kg	Infected plant parts develop a fuzzy grey growth under very high humidity. Remove all fading and diseased plant parts promptly, especially when wet weather is predicted. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Cercospora and Septoria leaf spot	Daconil Ultrex, 1.5 kg	Look for circular, distinct grey lesions encircled by purplish halos. Apply fungicides to protect leaves at the first sign of disease symptoms or preventively during periods of prolonged leaf wetness.

HYDRANGEA — hydrangea *continued*

	Pest	Product/1,000 L Water	Notes
DISEASES	Powdery mildew	MilStop, 2.8–5.6 kg	Powdery mildew appears as a white, powdery fungal growth on the tops of leaves. Early signs include small, circular whitish colonies. MilStop can be used for the suppression of powdery mildew. Start application of MilStop at the first sign of disease.
	Rust (various)	Daconil Ultrex, 1.5 kg	Look for small, orange pustules on the undersides of leaves in mid- to late summer. Protect healthy foliage with fungicides where disease incidence is severe. Rust on hydrangea rarely impacts plant health.

JUGLANS — butternut, walnut

	Pest	Product/1,000 L Water	Notes
INSECTS	Walnut blister mite *(Eriophyes erinea, Aceria erinea)*	Kelthane 50 W, 525–700 g	This mite feeds on walnut and butternut leaves, causing yellow or brown felt-like galls. Overwintering mites become active as new spring growth begins. Apply miticides to lower surfaces of newly emerged leaves.
	Walnut caterpillar *(Datana integerrima)*	Malathion 500 EC, 2.5 L Sevin 50 W, 1.0–1.5 kg	Larvae are black with long grey hairs. Larvae feed on walnut and hickory foliage. Caterpillar colonies descend tree trunks and molt, leaving a conspicuous clump of grey cast skins on the trunk. Adult moths lay eggs in early July, and larvae feed until the end of August. Spray when larvae first appear, usually in July. Feeding will continue into August and September. Spray or remove larvae clustering on the trunk.
DISEASES	Butternut canker *(Sirococcus clavigignenti juglandacearum)*		Dark brown-black cankers appear on branches and/or stems. Cankers are sunken, elongated and diamond-shaped. Dying branches can often be seen in the crown. Older cankers may show successive rings of callus loosely covered with bark. During spring, thin black fluid oozes from cracks in the bark and deposits a dried, sooty black stain. There is no known treatment for this disease.

JUNIPERUS — juniper

	Pest	Product/1,000 L Water	Notes
INSECTS	Juniper midge *(Contarinia juniperina)*	Cygon 480 E, 2.5 L	This midge is a problem on eastern red cedar, *Juniperus virginiana*. Tips of injured plant shoots turn brown during June and July due to midge larvae feeding from the previous summer. Injury is rarely serious. Adult midges are active from late May to July. If needed, treat the foliage at 2–3-week intervals beginning in late June.
	Juniper scale *(Carulaspis juniperi)* **[Plate 31]**	Diazinon 500 EC, 1.5 L DZN 600 EW, 1.25 L insecticidal soap, see label Landscape Oil, 15–20 L Malathion 500 EC, 2.5 L Sevin 50 W, 2–3 kg	Adults appear as a small, circular, white scale with a yellow centre. Needles of juniper and arborvitae will turn yellow. This scale insect can infest all juniper species, including Pfitzer and Savin. Juniper scale overwinters as eggs underneath the dead female shells, which makes dormant oil treatments ineffective. Sooty mould fungus sometimes develops. Treat crawlers about mid-June and repeat as needed, starting when *Philadelphus* is in full bloom and *Catalpa* are beginning to bloom. Do not use Malathion on Savin or Canaertii junipers.
	Juniper tip gall midge *(Rhopalicus* sp., *Oligotrophus betheli)*		These midge larvae cause galls to form on the ends of shoots. The adult is a chalcid wasp. Prune out green galls and destroy them to reduce the number of next-generation adults that emerge.

	Pest	Product/1,000 L Water	Notes
INSECTS	Juniper webworm *(Dichomeris marginella)*	Cygon 480 E, 2.5 L Lagon 480, 2.5 L Sevin 50 W, 2.0–3.0 kg	This webworm appears as a light brown caterpillar about 12 mm long. Larvae feed at the base of needles. Needles are webbed together during early fall and again the following spring. Treat foliage when larvae are active (late August and September).
DISEASES	Blight (dieback) *(Kabatina juniperi)* **[Plate 34]**	Copper Spray, 4.0 kg Dithane M-45, 80 WP, 2.75–3.5 kg	This blight appear as a dieback of new shoots. Stressed plants and wounded shoots are more susceptible. Avoid overhead irrigation late in the day. Do not crowd plants. Maintain adequate sunlight and good air circulation. If possible, prune out infected twigs well below the site of the symptoms. Dip pruners in disinfectant as frequently as possible. Maintain healthy growth, but do not encourage soft, succulent growth through excessive pruning or over-fertilization. Spray when spring growth starts. Repeat at 10-day intervals until growth stops. Laboratory diagnosis is needed to distinguish between *Kabatina* and *Phomopsis*.
	Cedar-apple rust *(Gymnosporangium juniperi-virginianae)* **[Plate 32]** Hawthorn rust *(G. globosum)* **[Plate 33]** Quince rust *(G. clavipes)*	Eagle WSP, 300 g (1 pouch in 280 L of water) Nova 40 W, 340 g	Cedar-apple rust and hawthorn rust cause slimy, orange galls on juniper twigs in mid-spring. When dormant, cedar-apple rust galls and hawthorn rust galls can be located in juniper foliage by their orange horns. Quince rust causes cankers in the twigs. Eagle WSP and Nova 40 W have the same active ingredient. Starting in mid-summer, apply Eagle WSP or Nova 40 W every 10–14 days when infected alternate rosaceous hosts (*Malus, Crataegus, Amelanchier,* etc.) are sporulating. To avoid resistance, rotate Eagle or Nova with registered fungicides from other chemical families where possible. Eagle or Nova can also be tank-mixed with Dithane DG (3 kg/ha). Prune out dormant galls and cankers on infected branches before May. Separate rosaceous rust hosts from junipers. Plant resistant junipers where possible.

LARIX — larch

	Pest	Product/1,000 L Water	Notes
INSECTS	Cutworms (various species)	Confirm 240 F, 0.5 L/ha Dylox, 2.75–4 L/ha Pounce, 180 mL/ha	Cutworms are moth larvae that hide in shallow soil burrows during the day and crawl up plant stems to harvest plant parts at night. Injury appears as chewed or girdled stems on woody species (and clipped stems on herbaceous plants). Larvae are greyish-brownish in colour, often with black spots along their sides and stripes along their body. They have three pairs of true legs, four pairs of fleshy prolegs and one pair of "claspers" at the end of their abdomen. They can be up to 3 cm long. Late instar larvae overwinter and pupate in spring. Use insecticides to reduce cutworm populations at the first sign of feeding injury. Treat plants with insecticides in the evening since the larvae feed at night. Applications of Confirm should be made with a high-volume spray and sprayed to run-off (for greenhouse use). Application of Pounce should be made under warm, moist conditions when larvae are small.
	Larch casebearer *(Coleophora laricella)*	Malathion 500 EC, 2.5 L	Larvae feed from within papery cases that resemble a killed needle. These straw-coloured larval cases protect larvae while they migrate to new feeding sites. Larvae will migrate from overwintering sites and fasten their cases to newly emerging foliage in spring. Larvae chew a hole into the green needle and mine the tissue within. Straw-coloured mined needles make the tree appear frost-damaged. Larvae feed in needles until late summer. Treat emerging needles with insecticides to reduce young larval populations in early spring.

LARIX — larch *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	Larch sawfly *(Pristiphora erichsonii)*	Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Sevin 50 W, 1.0–1.5 kg	Larvae are grey with black heads and can be up to 20 mm long. Larvae are active in mid- to late summer. Monitor for shepherd's crooks, caused by egg-laying, in the new growth. Treat foliage in July when larvae are still young.
	Tarnished plant bug *(Lygus lineolaris)* **[Plate 86]**	Ripcord 400 EC, 172 mL/ha	Plant bugs are small, yellowish-brown insects with a five-sided "shield" appearance to the wings. Tarnished plant bugs feed by inserting their mouthparts inside leaf tissue and sucking out the contents, leaving the lower and upper epidermis behind. The resulting injury appears as small, clear "windows" on leaf tissue of broad-leaved plants. On conifers, feeding often causes terminal growth to yellow and become distorted and bushy. Treat in spring and early summer to manage populations of this insect.
	Woolly larch adelgid *(Adelges laricis)*	Malathion 500 EC, 1.25 L	Adelgids feed on needles and are covered by waxy, woolly, cottony threads. Heavy infestations look like snow. Damaged leaves become bent or twisted. Treat foliage thoroughly when adelgids first appear.

LIGUSTRUM — privet

	Pest	Product/1,000 L Water	Notes
INSECTS	Privet rust mite *(Aculus ligustri)*	Kelthane 50 W, 525–700 g	Mites become active as new leaves emerge, from May to November. Damage appears as leaf russetting. Treat when mites first appear. Repeat as needed. This insect is more prolific in cooler weather.
	Privet thrips *(Dendrothrips ornatus)*	Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 500 mL Sevin 50 W, 2–3 kg Success 480 SC, 50 mL	These tiny, narrow insects suck plant sap from inide buds and newly emerging leaves. Injury appears as yellowish flecks on leaves. Leaves look greyish or dusty. Treat at the first sign of infestation and repeat as needed.
DISEASES	Anthracnose and twig blight *(Glomerella* sp.*)*	Nova 40 W, 340 g	Leaves turn brown and remain attached to twigs. Prune and destroy infected branches during dry weather. Spray fungicides to protect emerging shoots in spring. *Ligustrum amurense, L. x ibolium* and *L. obtusifolium* regelianum do not appear susceptible.
	Leaf spot *(Several fungi)*	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Nova 40 W, 340 g	Symptoms appear as brown spots on leaves, especially after a wet spring. Treat plants during prolonged wet conditions. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Rhizoctonia root rot	Compass 50 WG, 3.8 g/100 L	Rhizoctonia is a fungus that causes crown and root rot on several ornamentals. Lab testing will be necessary to confirm diagnosis. Protect healthy plants with fungicides at the first sign of disease.

LIRIODENDRON — tuliptree

	Pest	Product/1,000 L Water	Notes
INSECTS	Tuliptree aphid *(Macrosiphum liriodendri)*	insecticidal soap, see label Malathion 500 EC, 1.25 L *Thiodan 4 EC, 1.25–1.75 L Tristar 70 WSP, 3 solupaks Trounce, 50 L	This is a green aphid found on the underside of leaves from late June to late September. Treat when aphids first appear and repeat as needed. Excessive fertilization or pruning can cause excessive, susceptible succulent growth that is attractive to insects. ** Thiodan is toxic to fish.*
	Tuliptree scale *(Toumeyella liriodendri)*	horticultural oil, 20 L Landscape Oil, 20–30 L Malathion 500 EC, 2.5 L Sevin 50 W, 2–3 kg	This scale insect appears as a dark brown, rounded scale. Tuliptree scale attacks several deciduous tree species. Use horticultural oil as a dormant treatment in early spring. Use any of the other materials when crawlers appear in August. Landscape Oil can be used when plants are dormant or in summer when new foliage is fully expanded and hardened off. See product label.

LONICERA — honeysuckle

	Pest	Product/1,000 L Water	Notes
INSECTS	Honeysuckle aphid *(Hyadaphis tataricae)*	insecticidal soap, see label Malathion 500 EC, 1.25 L Tristar 70 WSP, 3 solupaks	Feeding injury from this aphid causes early-season curling and dwarfing of terminal shoots. Affected stems eventually die, causing a witches' broom. Injury may completely disfigure heavily affected plants. Dead shoots may be visible the following spring. Prune out witches' brooms from the previous season before buds begin to break in the spring. Apply horticultural oil after pruning to supress overwintering eggs. Apply treatment when buds begin to break. Repeat at least once after a 3-week interval. Susceptible varieties include *Lonicera x bella* 'Dropmore,' *L. korolkowii* 'Zabelli,' *L. tatarica* 'Grandiflora,' 'Rosea,' 'Hack's Red,' and 'Red Giant.'
DISEASES	Honeysuckle blight *(Herpobasidium deformans)*	Dithane DG, 2 kg	This is not a common disease in most of Ontario. Many species are susceptible. Symptoms appear as new leaves expand in spring. Infected leaves curl and turn brown. The veins tend to remain green at first. Spray fungicides when the leaf buds show a green tip or up to 1.25 cm of green leaf. Repeat applications in 10–14-day intervals. Avoid overhead irrigation late in the day. Remove and destroy infected leaf material to reduce inoculum the following spray.
	Powdery mildew	Nova 40 W, 340 g	This fungus appears as a white, powdery growth on the tops of leaves. Treat at the first sign of disease and repeat applications to protect healthy tissue.

MAGNOLIA — magnolia

	Pest	Product/1,000 L Water	Notes
INSECTS	Magnolia scale *(Neolecanium cornuparvum)* **[Plates 35 and 36]**	horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20–30 L Malathion 500 EC, 2.5 L Orthene 75 WP, 1.75 kg Sevin 50 W, 2–3 kg	Mature scales are large (up to 1 cm) and pinky-orange in colour. Feeding injury causes honeydew, sooty mould and twig dieback on *Magnolia acuminata*, *M. x soulangiana* and *M. stellata*. Nymphs of this large scale are purple in mid-summer, turning white by late summer. Nymphs overwinter as tiny nymphs on the current season's wood. Dormant oil applications can suppress overwintering nymphs in fall and/or early spring. Landscape Oil can be used when plants are dormant or in summer when new leaves are fully expanded and hardened off. See product label.

MALUS — apple

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various) **[Plate 37]**	Cygon 480 E, 1.25 L Endeavor, 100–200 g insecticidal soap, see label Lagon 480, 1.25 L Malathion 500 EC, 1.25 L *Thiodan 4 EC, 1.25 L Tristar 70 WSP, 3 solupaks Trounce, 50 L	Aphids are small, soft-bodied insects that feed by sucking on plant tissue. They produce honeydew that often attracts other insects (e.g., ants) and sooty mould. Treat when adults first appear, and repeat as required. ** Thiodan is toxic to fish.*
	Apple rust mite *(Aculus schlechtendali)*	Dyno-Mite, 284 g/ha Landscape Oil, 20–30 L	Adult females overwinter in bark crevices or cracks in twigs. When leaves begin to emerge, the overwintered females move to feed on the new leaf tissue. Apple rust mites feed on both surfaces of host tree leaves, causing them to turn brown and dry. The first symptom of infestation is an upward curling of the leaf. Severe infestation can result in all the leaves turning brown. Dyno-Mite can be applied as soon as mites appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Landscape Oil can be used when plants are dormant to control overwintering females in bark and twig crevices. Bark injury may occur on Red Delicious, Empire and Mutsu apples. See product label.
	Codling moth *(Cydia pinonella)*	Confirm 240 F, 1 L/ha (330–600 mL/1,000 L water)	Apply Confirm at larval hatch. Allow 3–7 days for larval mortality. Repeat the application of Confirm every 14–21 days, with a maximum of four applications per year.
	Eastern tent caterpillar *(Malacosoma americanum)* **[Plate 40]**	Diazinon 500 EC, 925 mL Dipel 132 ES, 0.5–1.0 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Malathion 500 EC, 2.5 L Pounce, 90 mL Sevin 50 W, 2.0–3.0 kg Success 480 SC, 25 mL Thuricide, 1.5–2.0 L	This caterpillar has one white stripe down its back. Colonies feed early in the season. Silken tents appear in the forks of branches, mainly of apple, cherry and hawthorn trees. Prune and destroy overwintering egg masses. These are silver in colour, about 1–2 cm long, in a raised band circling a twig. They hatch when buds break in spring. Treat then or at the first sign of webs. Where infestations are light, remove and destroy the tents (which contain larvae) in early spring.
	European red mite *(Panonychus ulmi)*	Dyno-Mite, 284 g/ha horticultural oil, 20 L insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Landscape Oil, 20–30 L Vendex 50 W, 0.5–1.0 kg	These mites overwinter as tiny red eggs on twigs. Apply oil when plants show 1.25 cm of green tissue. Bark injury may occur on Red Delicious, Empire and Mutsu apples. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Landscape Oil can be applied when plants are dormant and in summer when new leaves are fully expanded and hardened off. Bark injury may occur on Red Delicious, Empire and Mutsu apples. See product label.
	Fall cankerworm *(Alsophila pometaria)* **[Plate 38]** Spring cankerworm *(Paleacrita vernata)* **[Plate 39]**	Dipel 132 ES, 0.5–1.7 L/ha Foray 48 B, 1.0–1.6 L/ha Malathion 500 EC, 2.5 L Pounce, 90 mL Sevin 50 W, 2.0–3.00 kg Thuricide, 1.5–2.0 L	Cankerworms are greenish-to-black loopers (inchworms) that appear early in the season and feed on the leaves of many deciduous hosts. Place sticky bands around tree trunks, close to the ground, in the spring and fall. This traps adult females as they emerge from the ground and crawl up the tree trunk. Treat when larvae appear in mid-May, when *Acer platanoides* and *Magnolia x soulangiana* are blooming.

	Pest	Product/1,000 L Water	Notes
INSECTS	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).
	Japanese beetle *(Popillia japonica)* **[Plates 74 and 75]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin XLR PLUS, 2.3–3.5 L	Japanese beetle adults are metallic green and copper, about 13 mm long. They are easily recognized by the six tufts of white hair on each side of the abdomen. As the beetles feed, they consume and skeletonize foliage. Preferred hosts include members of the rosaceous family, maple, birch, linden and fruit trees. Spray adulticides when adults appear in early July, when the *Yucca filamentosa* is blooming. Larvae are C-shaped milky-white grubs (about 25 mm long) with brown heads and three pairs of legs. They can be distinguished from other white grubs by a V-shaped arrangement of spines on the underside of the abdomen. Larvae are most commonly found feeding on fibrous roots of turfgrass. Dursban T is a rescue treatment to allow shipping from infested to uninfested regions. Apply to soil when grubs are young and actively feeding near the soil surface. Apply as a coarse spray and irrigate with 1–2 cm of water to wash the insecticide into the underlying soil. For containerized stock, submerge the root ball into a solution of Dursban T (45 mL/10 L water) until all bubbling stops. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	Leafhopper (several species) **[Plate 41]**	Imidan 50 WP, 1.25 kg Sevin 50 W, 2.0 kg Sevin T&O, 2.3–3.5 L Tristar 70 WSP, 5 solupaks	Leafhoppers are tiny, yellowish-green to pale-coloured insects that jump quickly when disturbed. Wingless nymphs will often "side step" quickly to hide from potential predators. Leafhoppers have piercing-sucking mouthparts that cause distorted foliage with black margins and yellowish flecks on the leaf surface. Check regularly for infestation of nursery crops when neighbouring farms are cutting alfalfa or hay. Hang yellow sticky traps in the canopy to monitor for leafhoppers. Check by disturbing plants or looking at the leaf bottoms for leafhopper nymphs or molted skins. Treat as required.
	Leafrollers: Fruit tree leafroller *(Archips argyrospila)* Redbanded leafroller *(Argyrotaenia velutinana)*	Dipel, see product label	Leafrollers are caterpillars that feed while hidden in folded or rolled leaves. Fruit tree and redbanded leafrollers primarily affect fruit trees but also attack many shade trees and ornamentals. Apply the insecticide to foliage soon after leaves unfold in early June.

MALUS — apple *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	Oystershell scale *(Lepidosaphes ulmi)*	Diazinon 500 EC, 1.25 L horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20–30 L Malathion 500 EC, 2.5	This scale insect infests over 125 species of forest, shade, fruit and ornamental trees. In heavy infestations, greyish scales completely encrust twigs and stems and can kill branches and trees. Mature females are 3 mm long and rounded in the rear. Since this scale insect overwinters as eggs under dead female shells, dormant treatments in fall and early spring are ineffective. Use insecticides against crawlers in late May. Repeat in 10 days, when *Spiraea x vanhouttei* is blooming. Ensure good coverage of trunk, branches and leaf bottoms. Landscape Oil can be applied when plants are dormant and in summer when new leaves are fully expanded and hardened off. Bark injury may occur on Red Delicious, Empire and Mutsu apples. See product label.
	Tentiform leafminer *(Phyllonorycter blancardella)*	Confirm 240 F, see product label Tristar 70 WSP, 5 solupaks	Use insecticides to control the first generation during the prebloom or calyx stage. Early mines are only visible from lower leaf surfaces. Later stages are visible from upper leaf surfaces. There are three generations per year. Controlling the first generation is more effective than controlling subsequent generations.
	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)
	Western flower thrips *(Frankliniella occidentalis)*	Success 480 SC, 50 mL	Western flower thrips will feed from inside terminal vegetative buds and flower buds. They have piercing, sucking mouthparts that suck out plant juices of immature leaves and flowers, resulting in major distortion and colour flecking when flowers and foliage do emerge. Western flower thrips can feed openly on new leaves or within the tissue of the bud. Injury may be confused with that of leafhoppers. Do not make more than three applications of Success 480 SC per year.

	Pest	Product/1,000 L Water	Notes
DISEASES	Apple scab *(Venturia inaequalis)* **[Plate 43]**	Banner MAXX, 140 mL Captan 50 WP, 2.0 kg Captan 80 WDG, 1.25 kg Compass 50 WG, 140–175 g Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Dithane DG, M-45, 80 WP, 2 kg Equal 65 WP, 1.08–2.25 kg/ha Maestro 80 DF, see label Manzate DF, 6 kg/ha Microscopic Sulphur, 6.5 kg Nova 40 W, 340 g Polyram 80 DF, see product label Serenade Max, 3–6 kg/ha Supra Captan 80 WDG, see label	Scab infection causes purplish blotches on leaves and lesions on fruit. Start fungicide applications when leaf buds begin to break. Repeat every 7–10 days during spring, especially in rainy weather. Nova is a triazole fungicide and should be rotated with fungicides of other chemical families to manage resistance. If disease spread stops after new leaves harden off, cease fungicide treatment. Clean up and remove/destroy fallen leaves. Prune to improve air circulation through the canopy. Try to use resistant cultivars.
	Cedar-apple rust *(Gymnosporangium juniperi-virginianae)*	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Dithane DG, M-45, 80 WP, 2 kg Ferbam 76 WDG, 1.25–2.25 kg Manzate DF, 6 kg/ha Nova W, 340 g Polyram 80 DF, 2.0 kg	Orange spots on leaf surface appear in early summer, followed by cream-coloured, finger-like structures on the underside of leaves by mid- to late summer. Remove alternate hosts (junipers) where possible. Treat with fungicides when sporulation (slimy orange galls) begins on alternate host *(Juniperus)*, in mid-spring. Spores from juniper can infect alternate rosaceous hosts *(Malus, Crataegus, Amelanchier*, etc.). Repeat fungicidal applications every 10–14 days if needed. Apply other registered fungicides twice to foliage, starting at spring bud break.
	Fire blight *(Erwinia amylovora)* **[Plate 42]**	Blightban, 370–500 g Bloomtime, 375–500 g Copper Spray, 1.25 kg Serenade Max 2.5–6 kg/ha	Fire blight affects succulent, vegetative growth. Dead, dry leaves persist on infected branches. Some cultivars are resistant to this disease. Spray bactericidal products at early bloom, full bloom and petal fall where weather is warm and humid and fire blight is a recurring problem. Avoid excessive pruning and nitrogen fertilization in spring. During dormancy, prune out infected branches about 30 cm below the cankered area when the tree is dry. Blightban and Bloomtime are biopesticides that may suppress fire blight.
	Powdery mildew *(Podosphaera leucotricha)*	Compass 50 WG, 140–175 g Funginex 190 DC, 2.5 L/ha Microscopic Sulphur, 6.5 kg Nova 40 W, 340 g Serenade Max, 3–6 kg/ha	In this disease, a white, powdery substance develops on the tops of leaves in summer. Powdery mildew may lead to stunting and leaf drop. Treat with fungicides when symptoms first appear. Repeat every 10–14 days as needed. To avoid resistance with Nova, rotate with registered fungicides from other chemical families where possible.

PACHYSANDRA — pachysandra

	Pest	Product/1,000 L Water	Notes
INSECTS	Euonymus scale *(Unaspis euonymi)* **[Plates 20 and 21]**	Cygon 480 E, 2 L horticultural oil, 20 L insecticidal soap, see label Lagon 480 E, 2 L Landscape Oil, 20–30 L Orthene 75 SP, 1.0 kg	This greyish, pear-shaped scale also affects bittersweet *(Celastrus)* and *Pachysandra*. It produces two generations a year; the second generation appears about 6 weeks after the first. Examine plants during the dormant season, prune out highly infested regions and use dormant oil. Apply insecticides as nymphs emerge. *Catalpa speciosa* are beginning to bloom at this time; *Kolkwitzia* and *Philadelphus* are also blooming. Repeat treatment after 7 days. Landscape Oil can be used when plants are dormant or in the summer when foliage is fully expanded and hardened off. See product label.

PHLOX — phlox

	Pest	Product/1,000 L Water	Notes
INSECTS	Powdery mildew	Folpan 50 WP, 2 kg MilStop, 2.8–5.6 kg Nova 40 W, 340 g Rhapsody, 10–20 L	Powdery mildew appears as a white, powdery fungal growth on the tops of leaves. Early signs include small, circular whitish colonies. MilStop and Rhapsody can be used for the suppression of powdery mildew. Start application at the first sign of disease.
	Rust (various)	Nova 40 W, 250–340 g	In this disease, orange-brown lesions form on leaves. Protect healthy tissue with fungicide applications, especially during warm, wet conditions.

PICEA — spruce

	Pest	Product/1,000 L Water	Notes
INSECTS	Bagworm *(Thyridopteryx ephemeraeformis)*	Dylox, 2.75–4 L/ha Lagon 480 E, 2 L Orthene 75 SP, see product label Sevin 50 W, 2–3 kg	This moth pest is a native of North America. It has a wide host range but is most commonly found on spruce. Look for masses of dead needles hanging like small bags from tips of branches. Eggs overwinter inside the bags. Larvae feed on needles, partially enclosed in a small woven case. Larvae form bags on branch tips in late summer and pupate inside. Males emerge and fly to bags containing flightless females to mate. As many as 1,000 eggs are laid inside each bag. Remove and destoy bags by early spring. Insecticides may be effective on young larvae only.
	Cooley spruce gall adelgid *(Adelges cooleyi)* **[Plates 44 and 45]**	Malathion 500 EC, 1.25 L Pyrate 480 EC, 375 mL Sevin 50 W, 2.0–3.0 kg *Thiodan 4 EC, 1.25–1.75 L	Nymphs of this adelgid feed inside long, plump galls on the current year's shoots of blue Colorado spruce, Engelmann spruce and Sitka spruce. Douglas fir is an alternate host. Feeding injury causes needles to twist and turn yellow. This adelgid does not form a gall on Douglas fir. Treat in early spring before bud break or in early October. Thoroughly cover crevices in the bark of terminal twigs and the bases of buds. On blue spruce, use only wettable powders to prevent foliage discolouration. If possible, remove and destroy galls in June. ** Thiodan is toxic to fish.*
	Cutworms (various species)	Confirm 240 F, 0.5 L/ha Dylox, 2.75–4 L/ha Pounce, 180 mL/ha	Cutworms are moth larvae that hide in shallow soil burrows during the day and crawl up plant stems to harvest plant parts at night. Injury appears as chewed or girdled stems on woody species (and clipped stems on herbaceous plants). Larvae are greyish-brownish in colour, often with black spots along their sides and stripes along their body. They have three pairs of true legs, four pairs of fleshy prolegs and one pair of "claspers" at the end of their abdomen. They can be up to 3 cm long. Late instar larvae overwinter and pupate in spring. Use insecticides to reduce cutworm populations at the first sign of feeding injury. Treat plants with insecticides in the evening since the larvae feed at night. Applications of Confirm should be made with a high-volume spray and sprayed to run-off (for greenhouse use). Applications of Pounce should be made under warm, moist conditions when larvae are small.
	Eastern spruce gall adelgid *(Adelges abietis)* **[Plate 46]**	horticultural oil, 20 L Malathion 500 EC, 1.25 L Sevin 50 W, 2–3 kg *Thiodan 4 EC, 1.25–1.75 L Tristar 70 WSP, 3 solupaks	Nymphs of these adelgids feed inside pineapple-shaped galls at the base of current-year shoots on Norway, white, red and black spruce. Old galls remain attached for long periods, turning black and making the tree look scraggly. With light infestations, remove and destroy galls before midsummer. Use horticultural oil as a dormant treatment. Use any of the other materials when adelgids migrate to new shoots in mid-May. On blue spruce, use only wettable powders to prevent foliage discolouration, and avoid horticultural oils. ** Thiodan is toxic to fish.*

	Pest	Product/1,000 L Water	Notes
INSECTS	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae appear as dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).
	June beetle *(Phyllophaga* sp.*)* European chafer *(Rhizotrogus majalis)* **[Plate 17]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L	These beetle larvae are referred to as "white grubs." They chew fibrous roots and girdle underground stems of many woody ornamentals (including *Cornus* sp.). Cultivate infested fields before planting, to expose grubs to natural predators. Sevin T&O is registered as a foliar spray for adults. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	Pine needle scale *(Chionaspis pinifoliae)* **[Plates 54 and 55]**	Cygon 480 E, 1.5 L DZN 600 EW, 1.25 L horticultural oil, 20 L insecticidal soap, see label Lagon 480, 1.5 L Landscape Oil, 10–15 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg	Pine needle scale causes whitish flecks on pine and spruce needles. Reddish crawlers appear in late May, then turn yellowish. There are two generations per year. Infestations often start on lower branches. Prune out small infestations in late winter and early spring. Dormant treatments are ineffective because pine needle scale overwinter as eggs underneath the dead female shells. Crawlers are active when *Syringa vulgaris* and *Spiraea x vanhouttei* are blooming in late May. Treat at that time and again about 10 days later. Landscape Oil can be applied when plants are dormant and in summer when foliage is fully expanded and hardened off. Permanent discolouration of foliage will occur to *Pinus strobus* and blue cultivars of both *Juniperus* and *Picea*. See product label.
	Spruce bud scale *(Physokermes piceae, P. hemieryphus)*	horticultural oil, 20 L insecticidal soap, see label Lagon 480 E, 1.5 L Landscape Oil, see label Malathion 500 EC, 2.5 L	This scale insect is a rounded, mahogany-brown scale that clusters on spruce. Lower branches become ragged, with some dieback. Monitor for honeydew and sooty mould. Spray to control the crawlers in mid-July. Repeat 10 days later. Landscape Oil can be applied when plants are dormant and in summer when new leaves are fully expanded and hardened off. Permanent discolouration of foliage will occur to blue cultivars of both *Juniperus* and *Picea*. See product label.
	Spruce budworm *(Choristoneura fumiferana)* Also see under ABIES **[Plate 1]**	Cygon 480 E, 1.5 L Dipel, see product label Dragnet, 160 mL Foray 48 B, 1.6–2.4 L/ha Lagon 480, 1.5 L Lannate L, 1.25–1.75 L Malathion 500 EC, 2.5 L Mimic 240 LV, 290 mL/ha Pounce, 45–90 mL Sevin 50 W, 1.1–2.2 kg Thuricide, see product label	This is a widespread and important defoliator of balsam fir and spruce. It is seldom a problem on landscape trees. Larvae begin to feed as buds break, and they continue to feed until mid- to late June. They have a black head and brownish body with four light spots on the back of each segment. There is one generation per year. In mid-spring, apply general coverage spray to control larvae. Use Mimic to control early instar larvae; allow 3–7 days for larval mortality. A second application of Mimic may be needed. On balsam fir, overwintering larvae become active about 2 weeks before bud break. Apply general coverage spray to control larvae from mid-May to mid-June.

PICEA — spruce *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	Spruce needleminer *(Taniva albolineana, Endothenia albolineana)* **[Plate 48]**	Lagon 480 E, 1.5 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg	Needleminer larvae bore into the bases of old needles. Young larvae feed in groups, while older larvae feed alone. Larvae build unsightly nests of dead needles and frass, held together by fine silk strands. Small grey moths appear throughout infested plants in late May and June. Apply control to foliage about mid-June and repeat in late June. In fall, or in spring before buds swell, dislodge nests with a strong stream of water.
	Spruce spider mite *(Oligonychus ununguis)* **[Plate 47]**	Cygon 480 E, 1.5 L Floramite SC, 625 mL horticultural oil, 20 L insecticidal soap, see label Kanemite 15 SC, 0.42–0.92 L Lagon 480, 1.25 L Landscape Oil, 10–15 L Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375–500 mL Vendex 50 W, 0.5–1.0 kg	Overwintered eggs hatch in early May, when *Amelanchier laevis* and *Magnolia x soulangiana* are in full bloom. Mites prefer older needles as feeding sites. To monitor for mites, use a hand lens to check the undersides of twigs and needles for tiny reddish eggs or brown mites with black backs. Shake a branch over a white sheet of paper and look for crawling specks. Apply miticides when mites first appear. Kanemite is effective against motile life stages but may also reduce egg viability. Use horticultural oil as a dormant treatment in early spring to target eggs and newly hatched nymphs. DO NOT USE horticultural oil (including Landscape Oil) on white pine. Landscape Oil can be used when plants are dormant or in summer when leaves are fully expanded and hardened off. See product label. Permanent discolouration of foliage will occur to blue cultivars of both *Juniperus* and *Picea*. To prevent foliar discolouration on blue Colorado spruce, use only wettable powders and avoid horticultural oil. If populations are still significant, make two applications of other miticides at 10-day intervals when mites exist in spring. Many predatory mites co-exist with pest mite populations. To conserve predatory mites, try miticides that have less impact on these beneficials, such as Vendex and Floramite.
	Strawberry root weevil *(Otiorhynchus ovatus)*	Pounce, 45–90 mL	Strawberry root wevil larvae are small, white, legless grubs that eat fibrous roots or strip bark from larger roots. The reddish-brown flightless adult is under 6 mm long and is much smaller than the black vine weevil. Adults hide during the day and feed at night. Adults are active in late June and early July, when *Wiegela florida* and *Syringa reticulata* are blooming. Adults injure plants by puncturing or girdling the current season's shoots while feeding. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. These pests have a large host range. Commonly injured plants include white cedar, spruce and juniper. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. Pounce is registered for use on seedlings. To test treatment safety, treat some conifer seedlings, especially pine, before treating a larger area.
	Tarnished plant bug *(Lygus lineolaris)* **[Plate 86]**	Ripcord 400 EC, 172 mL/ha	Plant bugs are small, yellowish-brown insects with a five-sided "shield" appearance to their wings. They feed by inserting their mouthparts inside leaf tissue and sucking out the contents, leaving the lower and upper epidermis behind. The resulting injury appears as small, clear "windows" on leaf tissue of broad-leaved plants. On conifers, feeding often causes terminal growth to yellow and become distorted and bushy. Treat in spring and early summer to manage populations of this insect.
	White pine weevil *(Pissoides strobi)* **[Plates 64 and 65]**		This is a small, brownish snout beetle that attacks only vertical terminals on pines and spruce. It kills at least 2 years' growth. Attacks cause crooked, forked or multiple-stemmed trees. Legless, white larvae are found in the terminal shoots. In April, spray the vertical terminals. Remove and destroy infested, flagging leaders in June and July.

	Pest	Product/1,000 L Water	Notes
INSECTS	Yellow-headed spruce sawfly *(Pikonema alaskensis)*	Dragnet, 160 mL Dylox, 2.75–4 L/ha Pounce, 45–90 mL Success 480 SC, 25 mL	Sawfly larvae overwinter as late instar larvae in spun cocoons in the soil under the host tree. Adult sawflies are reddish brown and 8–10 mm long. Adults emerge in mid-late spring to mate and lay eggs in the branches at the base of needles. Larvae are green with lighter longitudinal stripes and yellow-brown heads. They feed on needles for 4–6 weeks. Target pesticide applications to young larvae where possible.
DISEASES	Botrytis *(Botrytis cinerea)*	Rovral WP, 1.5–2 kg	This disease can be an issue on seedlings in cold storage. Look for grey, fuzzy mould on tissue. Treat with fungicides at the first sign of disease.
	Canker, branch dieback *(Cytospora valsa)* **[Plate 49]**		This canker is often associated with the death of scattered lower branches. The first symptoms are browning and needle loss. Norway and Colorado spruce are very susceptible. Prune out diseased branches and twigs when the bark is dry. Maintain good growing conditions. Avoid damaging the trunk and branches.
	Damping off, root rot and stem rot *(Phytophthora, Pythium)*	Subdue MAXX, 1.2 L/ha (drench)	Stem rot and root rot cause rapid dieback and mortality and are often characterized by reddish-brown discolouration of the cambium. Subdue MAXX can be used as a drench or a pre-incorporated treatment for media to help protect conifer seedlings and transplants from *Pythium* and *Phytophthora*. Subdue MAXX is registered on conifer seedbeds, plugs and 2-0 transplants only. See product label.
	Needlecast *(Rhizosphaera kalkhoffii)* **[Plate 50]**	Copper Spray, 4.0 kg Daconil 2787 F, 9.5 L Daconil Ultrex, 5.75 kg	Symptoms of needlecast appear between early spring and early summer when needles infected the previous season turn purple or lavender. By mid-season, infected needles drop, leaving only current season growth. Blue Colorado spruce is very susceptible. Apply first treatment in spring when new growth is 1–2 cm long. Repeat at 3–4-week intervals. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Tip blight *(Sirococcus conigenus)*	Copper Spray, 4.0 kg Daconil 2787 F, 3.6–6 L Daconil Ultrex, 2.9–3.6 kg	Apply first treatment in spring when new growth is 1–2 cm long. Repeat at 3–4-week intervals. Do not crowd plants. Maintain adequate sunlight and good air circulation.

PINUS — pine

	Pest	Product/1,000 L Water	Notes
INSECTS	Cutworms (various species)	Confirm 240 F, 0.5 L/ha Dylox, 2.75–4 L/ha Pounce, 180 mL/ha	Cutworms are moth larvae that hide in shallow soil burrows during the day and crawl up plant stems to harvest plant parts at night. Injury appears as chewed or girdled stems on woody species (and clipped stems on herbaceous plants). Larvae are greyish-brownish in colour, often with black spots along their sides and stripes along their body. They have three pairs of true legs, four pairs of fleshy prolegs and one pair of "claspers" at the end of their abdomen. They can be up to 3 cm long. Late instar larvae overwinter and pupate in spring. Use insecticides to reduce cutworm populations at the first sign of feeding injury. Treat plants with insecticides in the evening since the larvae feed at night. Applications of Confirm should be made with a high-volume spray and sprayed to run-off (for greenhouse use). Applications of Pounce should be made under warm, moist conditions when larvae are small.

PINUS — pine *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	European pine shoot moth *(Rhyacionia buoliana)* **[Plate 51]**	Cygon 480 E, 2 L Diazinon 500 EC, 1.5 L DZN 600 EW, 1.25 L Lagon 480 E, 2 L Sevin 50 W, 2.0–3.0 kg	These larvae are brown with black heads. They feed inside emerging shoots in spring. Feeding injury causes "hooking" of new candles and pitch proliferation. The adult is a small, orange-flecked moth, usually active in late June to early July. Egg hatch coincides with the bloom of *Catalpa speciosa*. There is one generation per year. In late April, apply spray to the area between buds on terminals and laterals. Do this when *Acer rubrum* and *Cornus mas* are blooming. Spray terminals about mid-July to prevent injury the following year. Delaying shearing until mid-July, will destroy many eggs. Use pheromone traps to monitor for adult activity.
	June beetle *(Phyllophaga* sp.*)* European chafer *(Rhizotrogus majalis)* **[Plate 17]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2.0–3.0 kg Sevin XLR PLUS, 2.3–3.5 L	These beetle larvae are referred to as "white grubs." They chew fibrous roots and girdle underground stems of many woody ornamentals (including *Cornus* sp.). Cultivate infested fields before planting, to expose grubs to natural predators. Sevin is registered as a foliar spray for adults. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	Northern pine weevil *(Pissoides approximatus)*	Sevin 50 W, 2.0–3.0 kg	This weevil can be a problem on all pines, especially nursery production. It is often found on *Pinus sylvestris*. Damage includes flagging and browning of new shoots and seedlings. Adult feeding injury may result in small, circular wounds at the base of the damage that exude pitch resin. Remove freshly cut stumps and recently dead and dying trees by late spring to eliminate adult breeding grounds. Stressed trees are most susceptible. To control adults, treat the tender bark of seedlings and young shoots of larger trees in April or late August.
	Pales weevil *(Hylobius pales)* **[Plate 52]**	Sevin 50 W, 2.0–3.0 kg	This is a small, brownish-black weevil that feeds on tender pine twig bark, causing branches to turn brown and die. This weevil is a common pest in nursery production. Larvae bore into stem tissue at the soil line, girdling the tree. The white, legless larvae have brown heads. Larvae feed in long underground tunnels along the wood grain and on the outside of major roots. Remove freshly cut stumps and recently dead and dying trees by late spring to eliminate adult breeding grounds. Stressed trees are most susceptible. To manage adults, treat the tender bark of seedlings and young shoots of larger trees in April or late August.
	Pine bark adelgid *(Pineus strobi)* **[Plate 53]**	horticultural oil, 20 L Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Tristar 70 WSP, 3 solupaks	This adelgid mainly affects white pine, although other pine species may be infested. Adelgids appear covered in white, woolly masses on trunks, stems and branches. In early spring, use horticultural oil on the trunk and branch bark as a dormant treatment. Do not apply oil to white pine. Apply other insecticides to newly hatched nymphs in mid-late May. Repeat the application in 2–3 weeks. Ensure good coverage.

	Pest	Product/1,000 L Water	Notes
INSECTS	Pine false webworm *(Acantholyda erythrocephala)* **[Plate 94]**		This insect is a web-spinning sawfly that feeds on pine. The larvae feed on clipped needles from the safety of their webbed and frass-covered masses on branches against the trunk (mainly white pine). Pine false webworms overwinter as late instar larvae and pupae in soil cocoons below the host. Adults emerge in early spring. Adults are large, black; the females have an orange head and the males have a yellow face. Adults can be seen flying around foliage in May. Eggs are laid end-to-end along needles of white pine. Larvae are yellowish-brown with two dark longitudinal stripes on each side and obvious antennae. The short thoracic legs and absence of fleshy, abdominal prolegs gives this insect a very wobbly appearance when it moves around. Apply a strong stream of water with sufficient pressure to penetrate the webbing and knock out larvae. In light infestations, hand pick or prune out nests.
	Pine needle scale *(Chionaspis pinifoliae)* **[Plates 54 and 55]**	Cygon 480 E, 1.5 L DZN 600 EW, 1.25 L horticultural oil, 20 L insecticidal soap, see label Lagon 480, 1.5 L Landscape Oil, see label Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg	Reddish crawlers appear in late May, then turn yellowish. Feeding injury causes yellow spots on pine and spruce needles. There are two generations per year. Infestations often start on lower branches. Prune out small infestations in late winter and early spring. Dormant treatments are ineffective because pine needle scale overwinter as eggs underneath the dead female shells. Crawlers are active when *Syringa vulgaris* and *Spiraea x vanhouttei* are blooming in late May. Treat at that time and again about 10 days later. Landscape Oil can be applied when plants are dormant and in summer when foliage is fully expanded and hardened off. Permanent discolouration of foliage will occur to *Pinus strobus* and blue cultivars of both *Juniperus* and *Picea*. See product label.
	Pine pitch mass borer *(Vespamima pini, Synanthedon pini)* **[Plates 56 and 57]**		Pinkish-white borer larvae feed inside bark and can be found on established pine trees in the landscape. Large pitch resin masses appear on trunks. This moth has a 2–3-year life cycle. Stressed and wounded plants are most susceptible. Maintain good tree health, since no registered chemical controls exist. Larvae and pupae are found under the pitch masses. They can be removed and killed. Remove severely infested trees.
	Pine root collar weevil *(Hylobius radicis)*		This weevil feeds on many species of pine. White, Scots and Austrian are most susceptible. Infested trees often appear in isolated pockets or on sandy soils. The white, legless, grub-like larvae feed at the root collar, causing the trunk to swell. Pitch resin masses mixed with soil also appear. Prune off bottom branches. Pull away fallen needles and other organic matter to expose a circular soil surface 30 cm from the trunk. This increases light and temperature at the tree base, discouraging adult weevils. In mid-June, treat bark with registered insecticides at the trunk base and the soil surface 20 cm out from the trunk. This will help decrease populations of adults and developing larvae.
	Pine sawflies (open feeding): European pine sawfly *(Neodiprion sertifer)* Redheaded pine sawfly *(Neodiprion lecontei)* **[Plates 58 and 59]**	Cygon 480 E, 1 L Dragnet, 160 mL Lagon 480, 1 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 g Pounce, 45–90 mL Pyrate 480 EC, 500 mL Sevin 50 W, 2–3 kg Success 480 SC, 25 mL Tristar 70 WSP, 3 solupaks	European pine sawfly has a dark-greenish body with dark longitudinal stripes and a black head. It appears in late May/June. Redheaded pine sawfly has a yellow body with six rows of black spots and a reddish head. It feeds on older foliage in July and August. Multiple generations can be present at one time and will attack all foliage. Initial feeding begins in small, easily removed colonies. Spot-treat foliage when small larvae are first observed feeding.

PINUS — pine *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	Pine shoot beetle *(Tomicus piniperda)* **[Plates 60, 61, 62 and 63]**		This introduced bark beetle was found in Ohio in 1992 and in Ontario in 1993. By 1994, it was declared a quarantinable pest. Pines from many areas of the province are subject to quarantine. The primary host is Scots pine, *Pinus sylvestris*. The 3-mm-long adult beetles tunnel within the current season's growth, causing flagging and dropping of shoots. Adult beetles overwinter at the base of trees (within the first 30 cm above the soil), just inside the outer bark. The adults start to emerge in February–March, when temperatures reach 10°C. They bore into bark to lay their eggs, causing sap to flow out of these wounds. The larvae form galleries in the bark, thereby destroying the cambium and weakening or killing the tree. Maintain plant health, since no registered chemical controls exist. Do not plant nursery pines and Christmas trees near abandoned pine plantations. To discourage egg laying, remove stumps, pine debris, dying trees and pruned limbs from the area by February 1. Place uninfested "trap logs" (with a diameter greater than 6 cm) to attract mating adults and destroy them by May 31. Contact the Canadian Food Inspection Agency for the *Pest Alert Factsheet* on pine shoot beetle.
	Pine spittlebug *(Aphrophora cribrata)*	Malathion 500 EC, 2.5 L Pyrate 480 EC, 88–150 mL Sevin 50 W, 2.0–3.0 kg	Several different pines are susceptible hosts for pine spittlebug, with Scots pine often heavily infested. Young nymphs feed on sap from new growth and cover themselves with white, foam-like spittle. Several nymphs may be found in one spittle mass. This pest rarely causes serious damage. Treat when spittle masses first appear in mid- to late May.
	Pine tortoise scale *(Toumeyella numismaticum, T. parvicornis)*	DZN 600 EW, 1.25 L horticultural oil, 20 L insecticidal soap, see label Landscape Oil, see label Malathion 500 EC, 2.5 L Sevin 50 W, 2–3 kg	This reddish-brown oval, convex scale, about 6 mm long, infests several kinds of pine. It removes plant sap and secretes large amounts of honeydew. Remove heavily infested limbs and trees in late winter and early spring. In late June, treat twigs to control nymphs. There are several natural predators. Landscape Oil can be applied when plants are dormant and in summer when foliage is fully expanded and hardened off. Permanent discolouration of foliage will occur to *Pinus strobus* and blue cultivars of both *Juniperus* and *Picea*. See product label.
	Spruce spider mite *(Oligonychus ununguis)* **[Plate 47]**	Cygon 480 E, 1.5 L Floramite SC, 625 mL horticultural oil, 20 L insecticidal soap, see label Kanemite 15 SC, 0.42–0.92 L Lagon 480, 1.25 L Landscape Oil Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375–500 mL Vendex 50 W, 0.5–1.0 kg	Overwintered eggs hatch in early May, when *Amelanchier laevis* and *Magnolia x soulangiana* are in full bloom. Mites prefer older needles as feeding sites. To monitor for mites, use a hand lens to check the undersides of twigs and needles for tiny reddish eggs or brown mites with black backs. Shake a branch over a white sheet of paper and look for crawling specks. Apply miticides when mites first appear. Kanemite is effective against motile life stages but may also reduce egg viability. Use horticultural oil as a dormant treatment in early spring to target eggs and newly hatched nymphs. DO NOT USE horticultural oil (including Landscape Oil) on white pine. Landscape Oil can be used when plants are dormant or in summer when leaves are fully expanded and hardened off. See product label. Permanent discolouration of foliage will occur to blue cultivars of both *Juniperus* and *Picea*. To prevent foliar discolouration on blue Colorado spruce, use only wettable powders and avoid horticultural oil. If populations are still significant, make two applications of other miticides at 10-day intervals when mites exist in spring. Many predatory mites co-exist with pest mite populations. To conserve predatory mites, try miticides that have less impact on these beneficials, such as Vendex and Floramite.

	Pest	Product/1,000 L Water	Notes
INSECTS	Strawberry root weevil *(Otiorhynchus ovatus)*	Pounce, 45–90 mL	Strawberry root weevil larvae are small, white, legless grubs that eat fibrous roots or strip bark from larger roots. The reddish-brown flightless adult is under 6 mm long and is much smaller than the black vine weevil. It hides during the day and feeds at night. Adults are active in late June and early July, when *Wiegela florida* and *Syringa reticulata* are blooming. Adults injure plants by puncturing or girdling the current season's shoots while feeding. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. These pests have a large host range. Commonly injured plants include white cedar, spruce and juniper. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. Pounce is registered for use on seedlings. To test product safety, treat some conifer seedlings, especially pine, before treating a larger area.
	Tarnished plant bug *(Lygus lineolaris)* **[Plate 86]**	Ripcord 400 EC, 172 mL/ha	These plants bugs are small, yellowish-brown insects with a five-sided "shield" appearance to the wings. Tarnished plant bugs feed by inserting their mouthparts inside leaf tissue and sucking out the contents, leaving the lower and upper epidermis behind. The resulting injury appears as small, clear "windows" on leaf tissue of broad-leaved plants. On conifers, feeding often causes terminal growth to yellow and become distorted and bushy. Treat in spring and early summer to manage populations of this insect.
	White pine aphid *(Cinara strobi)*	Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375 mL Tristar 70 WSP, 3 solupaks	These are black aphids that often cluster together on shoots. Look for honeydew and sooty mould on needles. Treat active stages in May.
	White pine weevil *(Pissoides strobi)* **[Plates 64 and 65]**		This is a small, brownish snout beetle that attacks only vertical terminals on pines and spruce. It kills at least 2 years' growth. Attacks cause crooked, forked or multiple-stemmed trees. Legless, white larvae are found in the terminal shoots. In April, spray the vertical terminals. Remove and destroy infested, flagging leaders in June and July.
	Zimmerman pine moth *(Dioryctria zimmermani)*	Cygon 480 E, 2 L Lagon 480, 2.0 L	These grey-green larvae cause pitch resin to collect on pine trunks. Pitch masses appear at the branch whorls, on the trunk, or on shoots near terminal branches. Individual branches may die back completely. Remove larvae from pitch masses in June and July. Prune damaged shoots and remove heavily infested trees. Chemical control is difficult. Spray bark thoroughly in late April to early May when overwintering larvae are breaking dormancy (when *Acer platanoides* is blooming). Treat again in mid-August when larvae hatch. Use pheromone traps to monitor adult activity.
DISEASES	Brown spot *(Scirrhia* or *Mycosphaerella)*	Daconil 2787 F, 9.5 L Daconil Ultrex, 5.75 kg	Apply treatment in spring when new growth is 12 cm long. Repeat at 3–4-week intervals. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Canker *(Ascocalyx abietina* or *Scleroderris abietina)*	Daconil 2787 F, 2.4–4.8 L Daconil Ultrex, 1.45–2.9 kg	This canker may affect many pine species, especially Scots and red pine. Trees under 2 m are most susceptible. Symptoms appear in spring after infection. Bases of infected needles turn reddish brown by May or June. Needles may be bent. Cool moist weather encourages infection. To reduce spread, prune out lower branches of pine windbreaks around nurseries. Apply treatment in spring when new growth reaches 1–5 cm. Repeat at 3–4-week intervals.

PINUS — pine *continued*

	Pest	Product/1,000 L Water	Notes
DISEASES	Damping off, root rot and stem rot *(Phytophthora, Pythium)*	Subdue MAXX, 1.2 L/ha (drench)	Stem rot and root rot cause rapid dieback and mortality and are often characterized by reddish-brown discolouration of the cambium. Subdue MAXX can be used as a drench or a pre-incorporated treatment for media to help protect conifer seedlings and transplants from *Pythium* and *Phytophthora*. Subdue MAXX is registered for conifer seedbeds, plugs and 2-0 transplants only. See product label.
	Diplodia tip blight *(Sphaeropsis sapinea* or *Diplodia pinea)* **[Plate 66]**	Copper Spray, 4.0 kg	New shoots do not elongate in spring. They appear brown and stunted by June. Recent research suggests this fungus sporulates all year round. Maintain tree health, since infection is difficult to manage. Apply fungicides at bud break, using a maximum of three applications per year at 2-week intervals to help protect new shoots. Removing infected branches does not reduce infection, since spores are also produced on seed cones. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Lophodermium needlecast *(Lophodermium seditiosum)* **[Plate 67]**	Copper Spray, 4.0 kg Daconil 2787 F, 2.4–4.8 L Daconil Ultrex, 1.45–2.9 kg Dithane DG, M-45, 80 WP, 2.5 kg Manzate DF, 2.5 kg	This fungus severely defoliates pines, especially Scots and Austrian pine. Only the current season's needles remain on the tree over winter. The previous season's needles turn red in late winter and early spring. Infected needles drop from late spring to early summer. Black football-shaped fruiting bodies appear on cast needles in mid-summer. Apply treatment in mid-July to early August before infection occurs. Repeat at 3–4-week intervals as required. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Sweetfern blister rust *(Cronartium comptoniae)*		This rust disease affects hard two- and three-needle pines, especially jack pine *(Pinus banksiana)*. It can cause serious losses in nurseries and young plantations. Cankers often appear on the trunk, less than 2 m above the ground. Trees with basal diameters of more than 8 cm seem resistant. Destroy diseased pines. Eliminate alternate hosts such as sweet fern *(Comptonia peregrina)* and sweet gale *(Myrica gale)* from plantations and from the immediate vicinity of pine nursery stock.
	Tip blight *(Sirococcus)*	Copper Spray, 4.0 kg Daconil 2787 F, 3.6–6 L Daconil Ultrex, 2.9–3.6 kg	Apply treatment in spring when new growth is 12 cm long. Repeat at 3–4-week intervals. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	White pine blister rust *(Cronartium ribicola)* **[Plate 68]**		This rust is a serious disease of five-needle pines, especially white pine, *Pinus strobus*. It infects the needles, eventually causing a perennial canker on branches and trunks. It can also cause an insignificant leaf spot. When plants are dormant, prune out girdled pine branches before the canker reaches the main stem. Prune infected, flagging branches 30 cm below the cankered area. Separate white pine nurseries and plantations from alternate host *Ribes* sp. by at least 600 m.

PLATANUS — London plane, sycamore

	Pest	Product/1,000 L Water	Notes
INSECTS	Anthracnose *(Apiognominia veneta)*	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Dithane DG, M-45, 80 WP, 2.75–3.5 kg Manzate DF, 2.75–3.5 kg	As with frost damage, new leaves turn black-brown. Light brown dead areas appear along the veins of mature leaves. Twigs that are 20–25 cm long may show signs of cankers and dieback. Treat up to three times, especially in cool, wet weather: as buds swell, at bud break and about 7 days later. Prune out and destroy cankered twigs and branches. Collect and remove fallen, infected leaves. Do not crowd plants. Maintain adequate sunlight and good air circulation.

POPULUS — poplar

	Pest	Product/1,000 L Water	Notes
INSECTS	Forest tent caterpillar *(Malacosoma disstria)* **[Plate 3]**	Dipel, 0.5–1.0 L/ha Foray, 1.0–1.6 L/ha Orthene 75 SP, 1.0 kg Pounce, 90 mL/ha Pyrate 480 EC, 500 mL Sevin 50 W, 2–3 kg Thuricide, 1.5–2.0 L	Forest tent caterpillar larvae are hairy with a series of keyhole- or footstep-shaped white spots along their backs (hence the phrase "white footsteps in the forest"). The larvae are present early in the season. They feed in colonies. Forest tent caterpillar larvae do not not form a tent on their host. Larvae may completely defoliate broadleaf trees, particularly poplars. Treat foliage in mid-to-late May to reduce populations of larvae. Orthene may damage sugar maple leaves.
	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gyspsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).
	Poplar and willow borer *(Cryptorhynchus lapathi)*	Pyrate 480 EC, 500 mL *Thiodan 4 EC, 1.25 L	This borer is a stout, black, rough-bodied snout beetle with pink outer wing covers. White, legless larvae honeycomb the trunks and larger branches of willows and poplars. Cut and destroy badly infected branches and trees before the end of June. Treat trunk and branch bark in mid-August and September with insecticides. ** Thiodan is toxic to fish.*
DISEASES	Canker (several different fungi)		Most poplar species are susceptible to canker, especially when stressed. Prune out and destroy infected branches during dry weather. Remove and destroy severely infected trees. Do not wound or injure trees. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Leaf spot (several fungi)	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Senator 70 WP, 1 kg	Brown spots appear on leaves, followed by defoliation. Collect and remove fallen infected leaves. Treat at bud break, then twice more at 10–14-day intervals. Applications of Senator can be repeated every 10–14 days, with a maximum of three applications per year.

POTENTILLA — potentilla

	Pest	Product/1,000 L Water	Notes
INSECTS	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbio, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It become actives during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

PRUNUS — black cherry, chokecherry, flowering cherry, pin cherry, peach, plum

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various)	Endeavor, 100–200 g insecticidal soap, see label Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375 mL *Thiodan 4 C, 1.25–1.75 L Tristar 70 WSP, 3 solupaks Trounce, 50 L	Aphids are small, soft-bodied insects that suck plant sap from stems and leaves. Injury appears as distorted foliage, and plants may be severely weakened. Treat when aphids first appear, and repeat as required. Excessive fertilization or pruning can cause undesirable succulent growth levels. ** Thiodan is toxic to fish.*
	Eastern tent caterpillar *(Malacosoma americanum)* **[Plate 40]**	Diazinon 500 EC, 925 mL Dipel 132 ES, 0.5–1.0 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Malathion 500 EC, 2.5 L Pounce, 90 mL Sevin 50 W, 2.0–3.0 kg Success 480 SC, 25 mL Thuricide, 1.5–2.0 L	This caterpillar has one white stripe down its back. Colonies feed early in the season. Silken tents appear in the forks of branches, mainly of apple, cherry and hawthorn trees. Prune and destroy overwintering egg masses. These are silver in colour, about 1–2 cm long, in a raised band circling a twig. They hatch when buds break in spring. Treat then or at the first sign of webs. In light infestations, remove and destroy the tents (which contain larvae).
	European red mite *(Panonychus ulmi)*	Dyno-Mite, 284 g/ha horticultural oil, 20 L Landscape Oil, 20–30 L Vendex 50 W, 0.5–1.0 kg	These mites overwinter as tiny red eggs on twigs. Apply oil when plants are dormant or show 2.5 cm of green tissue and flowers are in a tight cluster. This can improve control of European red mite. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart.

INSECTS

Pest	Product/1,000 L Water	Notes
Gypsy moth *(Lymantria dispar)* **[Plate 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).
Japanese beetle *(Popillia japonica)* **[Plates 74 and 75]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin XLR PLUS, 2.3–3.5 L	The adult beetles are metallic green and copper, about 13 mm long. They are easily recognized by six tufts of white hair on each side of the abdomen. As the beetles feed, they consume and skeletonize foliage. Preferred hosts include members of the rosaceous family, maple, birch, linden and fruit trees. Spray adulticides when adults appear in early July, when the *Yucca filamentosa* is blooming. Larvae are C-shaped milky-white grubs (about 25 mm long) with brown heads and three pairs of legs. They are distinguishable from other white grubs by a V-shaped arrangement of spines on the underside of the abdomen. Larvae are most commonly found feeding on the fibrous roots of turfgrass. Dursban T is a rescue treatment to allow shipping from infested to uninfested regions. Apply to soil when grubs are young and actively feeding near the soil surface. Apply as a coarse spray and irrigate with 1–2 cm of water to wash the insecticide into underlying soil. For containerized stock, submerge the root ball into a solution of Dursban T (45 mL/10 L water) until all bubbling stops. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
Leafrollers: Fruit tree leafroller *(Archips argyrospila)* Redbanded leafroller *(Argyrotaenia velutinana)*	Dipel, see product label	Leafrollers are caterpillars that feed while hidden in folded or rolled leaves. Fruit tree and redbanded leafrollers primarily affect fruit trees but also attack many shade trees and ornamentals. Apply insecticides to foliage soon after leaves unfold in early June.
Peachtree borer *(Synanthedon exitiosa)* Lesser peachtree borer *(Synanthedon pictipes)* **[Plates 69 and 70]**	*Thiodan 4 EC, 1.5 L	Peachtree borers attack tree/shrub bases of *Prunus* (e.g., *Prunus x cistena*) at the soil line. Lesser peachtree borers attack higher limbs and are found mainly on fruit tree species of *Prunus*. Adults are clear-winged moths and resemble wasps when flying. Borers overwinter in bark or wood as partly grown larvae. Feeding resumes in spring, with gum and frass accumulating near the burrows. Treat in mid- to late spring, when *Philadelphus* is blooming. Repeat twice at 3-week intervals. Spray with a gun and cover the trunk and scaffold limbs thoroughly. Use pheromone traps to monitor adult activity. ** Thiodan is toxic to fish.*
Pearslug *(Caliroa cerasi)*	insecticidal soap, see label Orthene 75 SP, 1.0 kg	Small, dark, clear-bodied sawfly larvae feed from the undersides of leaves and cause significant defoliation. Treat with insecticides at the first sign of larval damage.

PRUNUS — black cherry, chokecherry, flowering cherry, pin cherry, peach, plum *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check the undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)
	Uglynest caterpillar *(Archips cerasivorana)*	Sevin 50 W, 2.0–3.0 kg Sevin XLR PLUS, 1.058 L Thuricide, see product label	These caterpillar larvae are dark yellow-green with black heads. They favour low-growing shrubs as hosts. Larvae feed on choke, pin and black cherry. Webbed nests appear at branch ends between May and September. Prune out nests when found. Chemical control is seldom used.
DISEASES	Bacterial canker *(Pseudomonas syringae)*	Copper Spray, 6 kg (dormant rate)	This disease often develops after poly is removed from cold frames (container production) and plants experience extreme shifts in temperature. Apply bactericidal products before autumn rains and again when most leaves have fallen. Do not crowd plants. Maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth that is susceptible to this disease.
	Black knot *(Apiosporina morbosa* or *Dibotryon morbosa)*	Maestro 80 DF, 3.75–4.5 kg	Black knot causes large black swellings up to 10 cm long on branches and small twigs, eventually girdling and killing the branch. Spray fungicides at green tip, pre-bloom and blossom time. In late winter and early spring, prune and destroy infested twigs and branches 20–30 cm below knots. Eliminate wild or neglected *Prunus* species from the area.
	Blossom and twig blight *(Monilina fructicola)*	Captan 50 WP, 2.0 kg Captan 80 WDG, 1.25 kg Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Funginex 190 DC, 750 mL (or 2.5 L/ha)	This disease causes blossoms and new shoots to suddenly collapse and turn brown. Shoot or twig blight appears in early spring. Fruit will turn brown, rot and hang on the tree. Spray just before blossom buds open. Repeat in 10 days if wet weather persists. Prune out and destroy infected twigs. Remove infected fruit from the tree and the adjacent ground.
	Peach leaf-curl *(Taphrina deformans)*	Ferbam 76 WDG, 1.75–3.5 kg	Peach leaf-curl spores lodged in winter buds cause infections during spring. As leaves unfold in spring, they become puckered and curled. Thickened areas eventually turn pinkish. Infected leaves become weakened and drop. Apply fungicide in fall (preferred time) just after complete leaf drop OR apply in early spring just before buds swell.
	Powdery mildew	Compass 50 WG, 140–210 g	This fungus appears as a white, powdery growth on the tops of leaves. Apply fungicides at the first sign of disease and repeat applications to protect healthy foliage.

	Pest	Product/1,000 L Water	Notes
DISEASES	Shothole leaf spot *(Blumeriella jaapii)*	Captan 80 WP, 1.25–1.5 kg	In this disease, leaf spots appear as leaves expand to full size. New spots appear until late summer. Disease spots fall out with age, giving a shothole appearance. (Note that other problems cause similar symptoms.) Avoid overhead irrigation late in the day. Do not crowd plants. Maintain adequate sunlight and good air circulation.

PSEUDOTSUGA — Douglas fir

	Pest	Product/1,000 L Water	Notes
INSECTS	Cooley spruce gall adelgid *(Adelges cooleyi)* **[Plate 44]**	Malathion 500 EC, 1.25 L Pyrate 480 EC, 375 mL Sevin 50 W, 2.0–3.0 kg *Thiodan 4 EC, 1.25–1.75 L	Douglas fir is an alternate host for this insect. Open-feeding, woolly nymphs cause new needles of Douglas fir to twist and turn yellow. Cooley spruce gall adelgid does not form a gall on this host. To catch newly hatched nymphs as they migrate to new foliage, treat in early spring as buds are breaking and new foliage is emerging. **Thiodan is toxic to fish.*
	Tarnished plant bug *(Lygus lineolaris)* **[Plate 86]**	Ripcord 400 EC, 172 mL/ha	Plant bugs are small, yellowish-brown insects with a five-sided "shield" appearance to the wings. Tarnished plant bugs feed by inserting their mouthparts inside leaf tissue and sucking out the contents, leaving the lower and upper epidermis behind. The resulting injury appears as small, clear "windows" on leaf tissue of broad-leaved plants. On conifers, feeding often causes terminal growth to yellow and become distorted and bushy. Treat in spring and early summer to manage populations of this insect.
	Needlecast (various fungi)	Daconil Ultrex, 1.45–2.9 kg Dithane DG, M-45, 80 WP, 2.75–3.5 kg	Various pathogens cause needlecast diseases on this host. Protect emerging needles in spring with fungicide to reduce fungal infections.

PYRACANTHA — firethorn

	Pest	Product/1,000 L Water	Notes
INSECTS	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

PYRACANTHA — firethorn *continued*

	Pest	Product/1,000 L Water	Notes
DISEASES	Scab *(Spilocaea pyracanthae)*	Banner MAXX, 140 mL Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg	Scab infection causes dark zones on leaves that develop into yellow lesions. Infected leaves may drop, and dull scabs may appear on twigs and fruit. Plant scab-resistant cultivars. Clean up and destroy fallen leaves. Prune to improve air circulation through the canopy. Start fungicide applications when leaf buds begin to break. Repeat every 7–10 days during mid-spring, especially in rainy weather. Apply Banner MAXX every 14 days, beginning at the green tip of leaf buds. Rotate Banner with fungicides from other chemical families to avoid resistance. Do not exceed four applications of Banner per year. Stop treatments if no infection exists when foliage is hardened off.
	Fire blight *(Erwinia amylovora)* **[Plate 42]**	Copper Spray, 1.25 kg Serenade Max, 2.5–6 kg/ha	Fire blight affects succulent vegetative growth. Dead, dry leaves persist on infected branches. Spray bactericidal products at early bloom, full bloom and petal fall where weather is warm and humid and fire blight is a recurring problem. Avoid excessive pruning and nitrogen fertilization in spring. During dormancy, prune out infected branches about 30 cm below the cankered area when the tree is dry.

PYRUS — pear

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various)	Endeavor, 100–200 g Tristar 70 WSP, 3 solupaks	Aphids are small, soft-bodied insects that suck plant sap from stems and leaves. Injury appears as distorted foliage, and plants may be severely weakened. Treat when aphids first appear, and repeat as required. Do not make more than three applications of Endeavor per year. Do not apply more than 3 kg/ha of Endeavor per year.
	European red mite *(Panonychus ulmi)*	Dyno-Mite, 284 g/ha horticultural oil, 20 L Kanemite 15 SC, 2.1 L/ha Landscape Oil, 20–30 L Vendex 50 W, 0.5–1.0 kg	These mites overwinter as tiny red eggs on twigs. Apply horticultural oil when plants show 2.5 cm of green tissue and flower buds are in a tight cluster. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart.
	Pear rust mite *(Epitrimerus pyri)*	Dyno-Mite, 284 g/ha	Adult females overwinter in bark crevices or cracks in twigs. When leaves begin to emerge, the overwintered females move to feed on the bud scales. Pear rust mites feed on the leaves and fruit, causing browning of foliage and russeting on the skin of the fruit. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart.

	Pest	Product/1,000 L Water	Notes
INSECTS	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)
DISEASES	Fire blight *(Erwinia amylovora)* **[Plate 42]**	Copper Spray, 1.25 kg Blightban, 370–500 g Bloomtime, 375–500 g Serenade Max, 2.5–6 kg/ha	Fire blight affects succulent vegetative growth. Dead, dry leaves persist on infected branches. Some cultivars are resistant to this disease. Spray bactericidal products at early bloom, full bloom and petal fall where weather is warm and humid and fire blight is a recurring problem. Avoid excessive pruning and nitrogen fertilization in spring. During dormancy, prune out infected branches about 30 cm below the cankered area when the tree is dry. Blightban and Bloomtime are biopesticides that may suppress fire blight.

QUERCUS — oak

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphids (various)	insecticidal soap, see label Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375 mL *Thiodan 4 EC, 1.25–1.75 L Tristar 70 WSP, 3 solupaks	Aphids are small, soft-bodied insects that suck plant sap from stems and leaves. Injury appears as distorted foliage, and plants may be severely weakened. Treat when aphids first appear, and repeat as required. ** Thiodan is toxic to fish.*
	Fall cankerworm *(Alsophila pometaria)* **[Plate 38]** Spring cankerworm *(Paleacrita vernata)* **[Plate 39]**	Dipel 132 ES, 0.5–1.7 L/ha Foray 48 B, 1.0–1.6 L/ha Malathion 500 EC, 2.5 L Pounce, 90 mL Sevin 50 W, 2.0–3.00 kg Thuricide, 1.5–2.0 L	Cankerworms are greenish-to-black loopers (inchworms) that appear early in the season and feed on leaves of many deciduous hosts. Place sticky bands around tree trunks, close to the ground, in the spring and fall. This traps adult females as they emerge from the ground and crawl up the tree trunk. Treat when larvae appear in mid-May, when *Acer platanoides* and *Magnolia x soulangiana* are blooming.
	Golden oak scale *(Asterolecanium variolosum)*	Cygon 430 E, 2 L horticultural oil, 20 L insecticidal soap, see label Lagon 480, 2 L Landscape Oil, see label Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2.0 L Sevin 50 W, 2–3 kg	Yellowish-golden scale feeds in small pits on white and English oak twigs, branches and trunks. Infestations can cause branch dieback. Use horticultural oil as a dormant treatment in early spring. Use any of the other materials against crawlers in late June. Crawlers can appear on first year and current season wood. Landscape Oil can be used when the plants are dormant or in the summer when foliage has fully expanded and hardened off. See product label.

QUERCUS — oak *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).
	Lacebug *(Coruthuca arcuata)*	Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Sevin 50 W, 2–3 kg	Lacebugs are flat, rectangular insects, 4–6 mm long with broad, transparent, lacelike wing covers. Adults and nymphs feed on the underside of leaves. The leaves become pale and mottled, with white splotches. Lower leaf surfaces develop black and brownish dots. Heavily infested leaves may turn entirely brown and fall off. Most species have two generations a year. Lacebugs usually occur on a single host. Other trees commonly attacked by lacebugs include elm, hickory, linden, sycamore and walnut. Apply insecticides to leaf undersides when insects first appear.
	Lecanium or European fruit lecanium *(Lecanium corni)* **[Plate 4]**	horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20–30 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2.0 L Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 kg Trounce, 50 L	This scale infests many deciduous trees and shrubs. When adults are mature in late spring/summer they appear as a large, reddish-brown, spherical scale usually found on the underside of twigs. Use horticultural oil as early-spring dormant treatment to reduce populations of overwintering nymphs. To suppress crawlers, spray insecticides when the *Sambucus canadensis* begins blooming. Do not use Malathion on Crimson King maple. Orthene may damage sugar maple leaves.
	Oak leaf gall (several species) **[Plate 71]**		Many gall makers infest oak roots, bark, twigs, leaves, flowers and acorns. Each gall has a characteristic appearance. Many are conspicuous and interesting, but few cause serious damage.
	Oak leafminer *(Profenusa lucifex)*	Diazinon 500 EC, 1.0 L DZN 600 EW, 830 mL Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Sevin 50 W, 2.0–3.0 kg	Oak leafminer larvae cause flat, blister-like mines from mid-June to July. Larvae are pale with stubby black legs and are found inside hollowed-out tissue within the leaf. Early treatment is most effective. Treat foliage to control larvae beginning the first week of June.
	Oak leaftier *(Croesia semipurpurana)*	Sevin 50 W, 2.0–3.0 kg	Small, whitish larvae enter unopened buds in May. They feed on the young leaves, then tie the leaves together and shred the tissue. Treat with insecticides to reduce populations of larvae when leaves are partially expanded.

	Pest	Product/1,000 L Water	Notes
INSECTS	Oak red mite *(Oligonychus bicolor)*	Kelthane 50 W, 525–700 g Landscape Oil, see label Orthene 75 SP, 1.0 kg	Feeding from mites causes bronzing and bleaching of oak leaves. Treat upper leaf surfaces from mid-June to mid-July. Weather and predators often keep populations under control. Landscape Oil can be used when the plants are dormant or in the summer when foliage has fully expanded and is hardened off. See product label.
	Oak skeletonizer *(Bucculatrix ainsliella)*	Malathion 500 EC, 2.5 L Sevin 50 W, 2.0–3.0 kg	Small yellowish-green larvae skeletonize the lower surface of oak leaves. There is one generation in June and a second in August/ September. Treat foliage when damage first appears in mid-June. Repeat in August. Collect and destroy leaves in the autumn to reduce overwintering populations.
	Oak twig pruner *(Elaphidionoides villosus)*		This is a long-horned beetle that attacks oak and some other deciduous trees. Larvae tunnel inside the twigs. Foliage on infested branches begins to wilt in mid-summer, and damaged twigs fall to the ground. Collect and destroy fallen twigs before mid-May and in the autumn to remove pupae. Chemical control is difficult and impractical.
	Orangestriped oakworm *(Anisota senatoria)*	Malathion 500 EC, 2.5 L Sevin 50 W, 2.0–3.0 kg	The black larvae have orange or yellow stripes running lengthwise down the sides and back. Two stiff black horns project from the top of the second body segment. There are small, sharp spines on the other body segments. If necessary, treat in August when larvae are young and concentrated on the lower branches.
	Red oak clearwing moth *(Paranthrene simulans)* **[Plate 72]**		Larvae bore into the wood of red oak trees, causing dieback in the canopy and sometimes tree mortality. Look for large holes with sawdust on tree trunks. Bore holes and tunnels often ascend up into the trunk. Insert a piece of flexible wire in the bore hole to destroy larvae. Adults are clearwing moths and resemble wasps when they are flying. Monitor adult populations with clearwing moth pheromone traps in late spring. High densities of pheromone traps may interrupt mating in small stands of red oak.
DISEASES	Anthracnose *(Gnomonia quercina* or *Apiognomonia quercina)*	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Dithane DG, M-45, 80 WP, 2.75–3.5 kg Manzate DF, 2.75–3.5 kg	This disease appears as irregular leaf-margin browning on red and white oak. Areas between veins also turn brown. Anthracnose often develops after a cool, wet spring. Collect and destroy fallen leaves in the fall. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Chlorosis or leaf yellowing		This is a physiological problem for pin oak *(Quercus palustris)* and red oak *(Q. rubra)* on high pH soils (pH > 6). Chlorosis is also caused by poor soil conditions such as water logging and compaction.
	Leaf scorch **[Plate 73]**		Irregular browning appears on leaf margins and between veins in response to hot, dry conditions. It occurs late in the season and during dry weather.
	Leaf spot (several fungi)	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg	Well-defined brown or black spots appear on the leaves. Treat when plants are dormant or at bud swell. Do not crowd plants. Maintain adequate sunlight and good air circulation.

RHODODENDRON — rhododendron, azalea

	Pest	Product/1,000 L Water	Notes
INSECTS	Black vine weevil Taxus weevil *(Otiorhynchus sulcatus)* **[Plates 80 and 81]**	Nemasys H, BGreen, see label Sevin 50 W, 2.00–3.0 kg *Thiodan 4 EC, 1.25–1.75 L *Thionex 50 WP, 1.5 kg	The weevil larvae are small, white, legless grubs that eat fibrous roots or strip bark off larger roots. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. Larvae control is difficult. Adults are black snout beetles that hide in soil litter during the day and cut crescent-shaped notches in needle margins at night. They also attack arborvitae, euonymus, yew and hemlock. They are a significant pest in container production. The beetles have fused wing covers and cannot fly. To control adults, treat foliage, trunk bark and branches during the last week of June and in early July. Spray in the evening, as adult activity increases about an hour after sunset. Do not use Thiodan on Anderson yew. To test product safety, treat some conifer seedlings, especially pine, before treating a larger area. Entomopathogenic nematodes (e.g., *Heterohabditis* sp.) are available to help suppress populations of larvae. Nematodes work very well in infested containers but with less success in the field. Nematodes can be applied in late summer/early autumn and in mid-spring to suppress larval populations. See product label for complete directions. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. ** Thiodan and Thionex are toxic to fish.*
DISEASES	Dieback, canker *(Phytophthora)*	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Truban 25% EC, see product label Truban 30% WP, see product label	This canker is visible on the stem. Terminal buds and leaves turn brown and leaves droop and curl. This pathogen may also affect the root and crown, resulting in water-soaked tissue that turns brown. Treat with Daconil as new leaves emerge. Repeat every 7–14 days during wet weather. Prune out infected branches and avoid overhead irrigation late in the day. Do not crowd plants. Maintain adequate sunlight and good air circulation. Maintain media air porosity, and reduce watering where root rot exists. Do not grow near lilacs, a common host for this disease.
	Powdery mildew	Banner MAXX, 350 mL Nova 40 W, 340 g	Symptoms appear as white, powdery growth on the tops of leaves, especially during hot days and cool nights. Apply Nova at the first sign of disease and repeat every 10–14 days as required. Rotate fungicides with those from other chemical families to avoid resistance. Do not exceed a maximum of four applications per year.
	Stem rot of cuttings	Captan 50W, 8–15 g/10 L Captan 80 WDG, 5–9.4 g/10 L	Various fungi will cause a stem rot on *Rhododendron*. Protect cuttings with fungicides during the propagation phase and any time high moisture and humidity is a problem. When using Captan, dip cuttings for 20–30 min and drain before planting.
	Sudden oak death *(Phytophthora ramorum)*	Acrobat 50 WP, 450 g/ha Chipco Aliette WG, 5 kg/ha Subdue MAXX, 78–156 mL	Sudden oak death is a foliar blight and stem canker found on *Camellia, Rhododendron, Pieris, Kalmia, Viburnum* and *Syringa*. The Canadian Food Inspection Agency has designated it a quarantined pest. Apply preventive fungicides to protect growth during cool, wet conditions. For resistance management, rotate Subdue MAXX with other fungicides that belong to a different chemical group. Apply Acrobat 50 WP in at least 200 L of water per hectare.

RIBES — currant

	Pest	Product/1,000 L Water	Notes
INSECTS	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

ROBINIA — locust

	Pest	Product/1,000 L Water	Remarks
INSECTS	Locust borer *(Megacyllene robiniae)*	Pyrate 480 EC, 500 mL *Thiodan 4 EC, 1.25 L	Locust borer larvae are fleshy, white grubs that tunnel in black locust stems. Weakened trees break in the wind. Black and yellow beetles feed on goldenrod pollen in late summer. Remove and destroy heavily infested trees. Maintain tree vigour since chemical control is difficult. Treat bark or trunk and larger branches to control adult beetles from mid-August to late September (when goldenrod is blooming). ** Thiodan is toxic to fish.*
	Locust leafminer *(Odontota dorsalis)*	Orthene 75 SP, 1.0 kg Sevin 50 W, 2–3 kg	In their adult and larval stages, leafminers feed on black locust leaves. Heavy infestations make trees unsightly. There are two generations a year. The adult is a small, wedge-shaped black beetle with bright orange wing covers. To control adult beetles, treat foliage in spring, when leaves open fully, and in early July.

ROSA — rose

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various)	Cygon 480 E, 1.25 L Endeavor, 100–200 g insecticidal soap, see label Lagon 480 E, 1 L Tristar 70 WSP, 3 solupaks Trounce, 50 L	Aphids are small, soft-bodied insects that feed by sucking plant sap from tissue. Feeding injury often causes distortion of growth. Aphids produce honeydew that attracts ants and sooty mould. Do not make more than three applications of Endeavor per year. Do not apply more than 3 kg of Endeavor per hectare per year.
	Japanese beetle *(Popillia japonica)* **[Plates 74 and 75]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin XLR PLUS, 2.3–3.5 L	The adult beetles are metallic green and copper, about 13 mm long. They are easily recognized by six tufts of white hair on each side of the abdomen. As the beetles feed, they consume and skeletonize foliage. Preferred hosts include members of the rosaceous family, maple, birch, linden and fruit trees. Spray adulticides when adults appear in early July, when the *Yucca filamentosa* is blooming. Larvae are C-shaped milky-white grubs (about 25 mm long) with brown heads and three pairs of legs. Japanese beetle larvae are distinguishable from other white grub species by a V-shaped arrangement of spines on the underside of the abdomen. Larvae are most commonly found feeding on the fibrous roots of turfgrass. Dursban T is a rescue treatment to allow shipping from infested to uninfested regions. Apply to soil when grubs are young and actively feeding near the soil surface. Apply as a coarse spray and irrigate with 1–2 cm of water to wash the insecticide into the underlying soil. For containerized stock, submerge the root ball into a solution of Dursban T (45 mL/10 L water) until all bubbling stops. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	Leafhopper (several species) **[Plate 41]**	Imidan 50 WP, 1.25 kg Sevin 50 W, 2.0 kg Sevin T&O, 2.3–3.5 L Tristar 70 WSP, 5 solupaks	Leafhoppers are tiny, yellowish-green to pale-coloured insects that jump quickly when disturbed. Wingless nymphs will often "side step" quickly to hide from potential predators. Leafhoppers have piercing-sucking mouthparts that cause yellowish flecks on the leaf surface. Check regularly for infestation of nursery crops when neighbouring farms are cutting alfalfa or hay. Hang yellow sticky traps in the canopy to monitor for leafhoppers. Check by disturbing plants or looking at the leaf bottoms for leafhopper nymphs or molted skins. Treat as required.
	Rose chafer *(Macrodactylus subspinosus)*	Sevin 50 W, 2–3 kg *Thionex EC, 1.25–1.75 L	Rose chafer adults are slender, long-legged, tan beetles. They are densely covered with short, dull yellow hairs. Beetles swarm in early June and feed on the opening buds of many hosts. They later attack the flowers, fruit and foliage. The larvae feed mostly on turfgrass roots but may attack the roots of woody ornamentals. Monitor for rose chafer in June. It is often a problem in sandy soils. With small infestations, pick off beetles by hand. Adult control is difficult. Treat foliage thoroughly when beetles appear. ** Thionex is toxic to fish.*
	Roseslug *(Endelomyia aethiops, Allantus cinctus)*	insecticidal soap, see label Sevin 50 W, 2–3 kg Trounce, 50 L	These sawflies feed on the undersides of leaves from late May to mid-June. Treat both leaf surfaces with insecticides. *A. cinctus* may need a second treatment in mid- to late August.

	Pest	Product/1,000 L Water	Notes
INSECTS	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Cygon 480 E, 1.25 L Diazinon 500 EC, 1.25 L Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 0.42 L Kelthane 50 W, 525–700 g Lagon 480, 1.25 L Orthene 75 SP, 1.0 kg Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)
DISEASES	Bacterial canker *(Pseudomonas syringae)*	Clean Crop Copper Spray, 6.0 kg	Bacterial canker appears as a blackening of new tissue and is often associated with low-temperature events. Do not crowd plants. Maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth levels. Treat with copper once in October and once in January. Treat during blight conditions in April and May with 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals.
	Black spot *(Diplocarpon rosae)* **[Plate 76]**	Banner MAXX, 330 mL Captan 50 W, Captan 50 WP, 2–2.5 kg Captan 80 WDG, 1.2–1.4 kg Clean Crop Copper 53 W, 6.0 kg Daconil 2787, 1.8 L Daconil Ultrex, 1.1 kg Eagle WSP, 30 g/100 L (1 pouch in 280 L water) Funginex 190 DC, 1.0 L Nova 40 W, 340 g Senator 70 WP, 500–750 g	Black spot is a common disease on rose. It appears on leaves and stems as purplish black spots with yellow halos. Leaves may turn yellow and drop. Where possible, use resistant cultivars. Remove and destroy cankered canes. Where disease occurs, use fungicides every 7–10 days from mid-May (as leaves begin to emerge) until frost kills the foliage. Apply Eagle and/or Senator every 10–14 days and rotate with fungicides from other chemical families to avoid resistance. Reduce spray intervals in cool, wet weather. Eagle WSP and Nova 40 W have the same active ingredient. Avoid overhead irrigation, especially late in the day. A 6-hour period of wet foliage will permit infection to start. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Botrytis *(Botrytis cinerea)*	Botran 75, 1.75 kg Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg Senator 70 WP, 500–750 g	Botrytis can be an issue on roses in cold storage. Look for grey, velvety fungal growth on plants. Apply fungicide before lifting for storage. Repeat during storage. Apply fungicides at the first sign of disease, and repeat every 10–14 days if needed.
	Botrytis flower blight *(Botrytis cinerea)*	Captan 50 W, 2 kg Daconil 2787, 1.8 L Daconil Ultrex, 1.1 kg	Botrytis is a grey, velvety fungus that may grow on succulent tissue (e.g., flowers). Apply fungicides when the disease first appears, and repeat at 7–10-day intervals.
	Crown gall *(Agrobacterium tumefaciens)* **[Plate 24]**	Dygall, 160 g/50 L	This gall appears as large abnormal growths on stems and roots. Susceptible plants must be treated before disease exposure or final field placement. Wounding (e.g., pruning) and damaging plants facilitate infection of this pathogen. Remove and destroy infected plants. This is a soil-borne bacteria.

ROSA — rose *continued*

	Pest	Product/1,000 L Water	Notes
DISEASES	Downy mildew *(Peronospora sparsa)*		This fungus causes purplish to brownish blotches on the upper leaf surface. Under cool, moist conditions, slight symptoms of sporulation (fuzzy appearance) may be evident on the lower leaf surface below the lesion. These spores will disappear quickly once it warms up. Downy mildew infections often lead to premature leaf drop. Increase air circulation around susceptible plants and reduce leaf wetness periods by watering only in the mid-morning.
	Powdery mildew *(Sphaerotheca pannosa var. rosae)*	Banner MAXX, 350 mL Clean Crop Copper 53 W, 6 kg Eagle WSP, 30 g/100 L water (1 pouch in 280 L water) Folpan 50 WP, 2.0 kg Funginex 190 EC, 1.0 L Meltatox, 2.5 L MilStop, 2.8–5.6 kg Nova 40 W, 340 g Rhapsody, 10–20 L Senator 70 WP, 500–750 g sulphur, see label	This fungus appears as a white, powdery growth on leaves and shoot ends. Leaves become stunted and curled. Treat when symptoms first appear. Apply fungicides every 10 days. Apply Nova or Eagle every 10–14 days and rotate with fungicides from other chemical families to avoid resistance. Senator can be applied every 10–14 days as needed. Do not apply sulphur when temperatures exceed 27°C. Do not crowd plants. Maintain adequate sunlight and good air circulation. Overhead watering during the day may reduce the spread and development of the disease, but avoid overhead irrigation late in the day. MilStop can be used for the suppression of powdery mildew. Start application of MilStop at the first sign of disease. Rhapsody is a biological fungicide that can help protect healthy tissues at the first sign of disease.

SALIX — willow

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various)	Endeavor, 100–200 g insecticidal soap, see label Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375 mL *Thiodan 4 EC, 1.25–1.75 L Tristar 70 WSP, 3 solupaks Trounce, 50 L	Aphids are small, soft-bodies insects that feed by sucking on plant sap. Feeding causes distortion and weakens the plant. Treat when aphids first appear, and repeat as needed. Do not make more than three applications of Endeavor per year. Do not apply more than 3 kg of Endeavor per hectare per year. ** Thiodan is toxic to fish.*
	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Females lay eggs in brown fuzzy masses July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).

	Pest	Product/1,000 L Water	Notes
INSECTS	Imported willow leaf beetle *(Plagiodera versicolora)*	Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Sevin 50 W, 2–3 kg Success 480 SC, 25 mL	Adults are small, oval, metallic blue beetles. Adults and larvae skeletonize willow and Lombardy poplar leaves. There are two or more generations per year. Larvae are black, slug-like grubs. Treat at the first sign of leaf feeding after leaves appear, in late May to early June. Repeat the application in early July if necessary. A pupal parasite exists, so avoid insecticide applications at the time of pupation.
	Poplar and willow borer *(Cryptorhynchus lapathi)*	Pyrate 480 EC, 500 mL *Thiodan 4 EC, 1.25 L	This borer is a stout, black, rough-bodied snout beetle with pink outer wing covers. The white, legless larvae honeycomb the trunks and larger branches of willows and poplars. Cut and destroy badly infected branches and trees before the end of June. Treat trunk and branch bark in mid-August and September with insecticides. ** Thiodan is toxic to fish.*
	Spiny elm caterpillar *(Nymphalis antiopa)*	Malathion 500 EC, 2.5 L Sevin 50 WP, 2.0–3.0 kg	Adult moths are called the "mourning cloak butterfly." Larvae are black with scattered white dots and are covered with large, branched spines. They feed in groups on elm, willow and poplar. Treat when caterpillars first appear and are small.
	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of twice per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)
DISEASES	Blight scab and black canker complex		This fungal infection causes leaves to turn brown to black. Branches and twigs die back. Prune out infected wood. Do not crowd plants. Maintain adequate sunlight and good air circulation.

SORBUS — mountain ash

	Pest	Product/1,000 L Water	Notes
INSECTS	European red mite *(Panonychus ulmi)*	horticultural oil, 20 L Kanemite 15 SC, 0.42–0.92 L Landscape Oil, see label Malathion 500 EC, 1.25 L	Use horticultural oil as a dormant spray in early spring. Use other materials about late May. Apply horticultural oil when plants show 2.5 cm of green tissue and flower buds are a tight cluster. Landscape Oil can be used when the plants are dormant or in the summer when foliage has fully expanded and is hardened off. See product label.
	Fire blight *(Erwinia amylovora)* **[Plate 42]**	Copper Spray, 1.25 kg Serenade Max, 2.5–6 kg/ha	Fire blight affects succulent vegetative growth. Dead, dry leaves persist on infected branches. Spray bactericidal products at early bloom, full bloom and petal fall where weather is warm and humid and fire blight is a recurring problem. Avoid excessive pruning and nitrogen fertilization in spring. During dormancy, prune out infected branches about 30 cm below the cankered area when the tree is dry.
	Mountain ash sawfly *(Pristiphora geniculata)*	Malathion 500 EC, 2.5 L Sevin 50 W, 2.0–3.0 kg	Sawfly larvae are yellow with black spots on all body segments except the last one. There are four lines of spots along each side of the larvae. Two broken lines run down the back. Sawflies feed in colonies from June to early August. A second generation appears from late August to early September. Young larvae feed in colonies and are easily pruned out. Treat foliage to control larvae during late spring. Repeat the treatment in areas where the second generation appears in August.
	Pearleaf blister mite *(Eriophyes pyri* or *Phytoptus pyri)*	horticultural oil, 20 L Landscape Oil, see label Sevin 50 W, 2.0–3.0 kg	Feeding injury from this mite causes small blisters on the leaf undersides of pear, apple and mountain ash. There are several generations per year. Mites overwinter under the outer bud scales, resuming activity in the spring. Apply horticultural oil as a dormant treatment in the spring. Apply Sevin as a foliar spray. Landscape Oil can be used when the plants are dormant or in the summer when foliage has fully expanded and is hardened off. See product label.

SYRINGA — lilac

	Pest	Product/1,000 L Water	Notes
INSECTS	Japanese beetle *(Popillia japonica)* **[Plates 74 and 75]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin XLR PLUS, 2.3–3.5 L	The adult beetles are metallic green and copper, about 13 mm long. They are easily recognized by six tufts of white hair on each side of the abdomen. As the beetles feed, they consume and skeletonize foliage. Preferred hosts include members of the rosaceous family, maple, birch, linden and fruit trees. Spray adulticides when adults appear in early July, when the *Yucca filamentosa* is blooming. Larvae are C-shaped milky-white grubs about 25 mm long with brown heads and three pairs of legs. Larvae are distinguishable from other white grub species by a V-shaped arrangement of spines on the underside of the abdomen. Larvae are most commonly found feeding on fibrous roots of turfgrass. Dursban T is a rescue treatment to allow shipping from infested to uninfested regions. Apply to soil when the grubs are young and actively feeding near the soil surface. Apply as a coarse spray and irrigate with 1–2 cm of water to wash the insecticide into the underlying soil. For containerized stock, submerge the root ball into a solution of Dursban T (45 mL/10 L water) until all bubbling stops. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	June beetle *(Phyllophaga* sp.*)* European chafer *(Rhizotrogus majalis)* **[Plate 17]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin XLR PLUS, 2.3–3.5 L	These beetle larvae are referred to as "white grubs." They chew fibrous roots and girdle underground stems of many woody ornamentals (including *Cornus* sp.) . Cultivate infested fields before planting, to expose grubs to natural predators. Sevin is registered as a foliar spray for adults. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	Lilac borer *(Podosesia syringae var. syringae)* **[Plate 77]**	Pyrate 480 EC, 500 mL *Thiodan 4 EC, 1.25 L	Lilac borer larvae bore into the trunk near the base. Stressed trees are most susceptible to borers. Cut and destroy infested wood before May. Prevent mechanical damage to wood and bark. The adults are dark-brown, wasp-like moths, present from late May to late July. They emerge through holes 1–1.5 cm in diameter. They are clearwing moths and resemble wasps when flying. Use pheromone traps to monitor adult activity. Begin treatment 10 days after peak catch numbers. Treat trunk and large branches, especially around wounds. Repeat twice at 10-day intervals. ** Thiodan is toxic to fish.*
	Lilac leafminer *(Caloptilia syringella* or *Gracillaria syringella)* **[Plate 78]**	Cygon 480 E, 1.25 L Lagon 480, 1.25 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg	The adult is a small, dark brown moth, active in late May to early June. Larvae are pale yellow and feed between leaf surfaces, causing brown blotches to form. For small infestations, pick and destroy affected leaves. Treat when pest activity first appears, or apply insecticides initially in early June or immediately after flowering and repeat 6 weeks later. Privet *(Ligustrum)* is an alternate host.

SYRINGA — lilac *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	Oystershell scale *(Lepidosaphes ulmi)*	Diazinon 500 EC, 1.5 L Landscape Oil, see label Malathion 500 EC, 2.5 L insecticidal soap, see label Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2 L	Oystershell scale can be found on over 125 forest, shade, fruit and ornamental tree species. In heavy infestations, greyish scales completely encrust twigs and stems. This can cause branch and tree mortality. Mature females are 3 mm long and rounded at the rear, resembling oyster shells. Eggs overwinter under dead female shells, rendering them completely resistant to pesticides applied in fall or early spring. Use insecticides when crawlers are present in late May. Apply again 10 days later, about the time *Spiraea x vanhouttei* is blooming. Ensure good coverage of trunk, branches and leaf bottoms. Landscape Oil can be used in the summer when leaves are fully expanded and hardened off. See product label.
DISEASES	Bacterial canker *(Pseudomonas syringae)*	Copper Spray, 6 kg (dormant rate)	In this disease, young shoots or leaves turn black between early spring and early summer, especially during wet, cool weather. Bacterial canker can kill young twigs during wet springs. It can be found on container-grown plants after poly has been removed from the cold frame in early spring. It is commonly found after low-temperature injury. Apply treatment once in October and again in January. During blight conditions in April and May, apply 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals. Avoid overhead irrigation late in the day. Prune out infected twigs. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Powdery mildew *(Microsphaera alni)* **[Plate 79]**	Nova 40 W, 340 g sulphur, see label	This white-to-grey powdery mould appears on leaves in late summer and early autumn. It does not usually require chemical control. Do not crowd plants. Maintain adequate sunlight and good air circulation. Overhead watering during the day may reduce the spread and development of this disease, but avoid overhead irrigation late in the day. Apply fungicide when first symptoms appear in mid- to late August. Repeat at 5–10 day intervals. Do not apply sulphur when temperatures exceed 27°C.
	Rhizoctonia root rot	Compass 50 WG, 3.8 g/100 L	Rhizoctonia causes a stem blight and root rot at or below the soil line. Lab testing is needed to confirm the identification of this disease. Protect healthy plants with fungicides at the first sign of disease.

TAXUS — yew

	Pest	Product/1,000 L Water	Notes
INSECTS	Black vine weevil Taxus weevil *(Otiorhynchus sulcatus)* **[Plates 80 and 81]**	Nemasys G, BGreen, see label Sevin 50 W, 2.00–3.0 kg *Thiodan 4 EC, 1.25–1.75 L *Thionex 50 WP, 1.5 kg	The weevil larvae are small, white, legless grubs that eat fibrous roots or strip bark off larger roots. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. Larvae control is difficult. Adults are black snout beetles that hide in lower branches and soil litter during the day and cut crescent-shaped notches in needle margins at night. They also attack arborvitae, hemlock, azaleas and rhododendrons. The beetles have fused wing covers and cannot fly. To control adults, treat foliage, trunk bark and branches during the last week of June and in early July. Spray in the evening, as adult activity increases about an hour after sunset. Do not use Thiodan on Anderson yew. To test product safety, treat some conifer seedlings, especially pine, before treating a larger area. Entomopathogenic nematodes (e.g., *Heterohabditis* sp.) are available to help suppress populations of larvae. Nematodes work very well in infested containers but with less success in the field. Nematodes can be applied in late summer/early autumn and in mid-spring to suppress larval populations. See label for complete directions. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. ** Thiodan and Thionex are toxic to fish.*
DISEASES	Fletcher scale *(Lecanium fletcheri)* **[Plate 82]**	Cygon 480 E, 2 L Diazinon 500 EC, 1.25 L DZN 600 EW, 1.25 L insecticidal soap, see label Lagon 480, 2 L Landscape Oil, 10–15 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1 kg Sevin 50 W, 2–3 kg	The adult is a reddish-brown sphere that appears on branches. Look for black sooty mould and honeydew on the needles in mid-late spring. Heavily infested plants look off-colour. Treat newly emerged crawlers in early July when *Yucca filamentosa* is blooming, or in September when the nymphs migrate. Repeat the application in about 10 days to catch all nymphs. Apply horticultural oils when plants are dormant. Apply Landscape Oil to target crawlers when new foliage is fully expanded and hardened off. See product label.
	Taxus mealybug *(Pseudococcus cuspidatae* or *Dysmicoccus wistariae)*	Cygon 480 E, 2 L Diazinon 500 EC, 1.5 L insecticidal soap, see label Lagon 480, 2 L Landscape Oil, 10–15 L Malathion 500 EC, 2.5 L Sevin 50 W, 2–3 kg Trounce, 50 L	Taxus mealybug is a slow-moving, white, woolly insect that can completely cover heavily infested branches and trunks with a waxy secretion. Feeding discolours needles and causes excessive needle cast. This mealybug attacks all yew species. Use insecticide on the bark of small branches and twigs to control nymphs when the *Aesculus hippocastanum* is blooming. Apply horticultural oils when plants are dormant. Apply Landscape Oil to target nymphs when new foliage is fully expanded and hardened off. See product label.

THUJA — eastern white cedar, arborvitae

	Pest	Product/1,000 L Water	Notes
INSECTS	Black vine weevil Taxus weevil *(Otiorhynchus sulcatus)* **[Plates 80 and 81]**	Nemasys G, BGreen, see label Sevin 50 W, 2.00–3.0 kg *Thiodan 4 EC, 1.25–1.75 L *Thionex 50 WP, 1.5 kg	The weevil larvae are small, white, legless grubs that eat fibrous roots or strip bark off larger roots. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. Larvae control is difficult. Adults are black snout beetles that hide in soil litter during the day and cut crescent-shaped notches in needle margins at night. They also attack euonymus, hemlock, yew, azaleas and rhododendrons. They can be a significant pest in container production. The beetles have fused wing covers and cannot fly. To control adults, treat foliage, trunk bark and branches during the last week of June and in early July. Spray in the evening, as adult activity increases about an hour after sunset. Do not use Thiodan on Anderson yew. To test treatment safety, treat some conifer seedlings, especially pine, before treating a larger area. Entomopathogenic nematodes (e.g., *Heterohabditis* sp.) are available to help suppress populations of larvae. Nematodes work very well in infested containers but with less success in the field. Nematodes can be applied in late summer/early autumn and in mid-spring to suppress larval populations. See label for complete directions. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. ** Thiodan and Thionex are toxic to fish.*
	Cedar leafminer Arborvitae leafminer *(Argyresthia thuiella* and other species) **[Plate 84]**	Cygon 480 E, 2 L DZN 600 EW, 830 mL Lagon 480, 2 L Malathion 500 EC, 2.5 L	Four caterpillar species mine cedar foliage, but *A. thuiella* is the most common. Feeding causes branch tips to turn brown. The adult is a small, light-grey moth that appears in late June to early July. Prune out infected tips before June to provide some suppression. To manage larvae, spray with Cygon in early May or late August. Use Malathion in June to suppress populations of adult moths.
	Fletcher scale *(Lecanium fletcheri)* **[Plate 82]**	Cygon 480 E, 2 L Diazinon 500 EC, 1.25 L DZN 600 EW, 1.25 L insecticidal soap, see label Lagon 480, 2 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1 kg Sevin 50 W, 2–3 kg Trounce, 50 L	The adult is a reddish-brown sphere that appears on branches. Look for black sooty mould and honeydew on the needles in mid-late spring. Heavily infested plants look off-colour. Treat newly emerged crawlers in early July when *Yucca filamentosa* is blooming, or in September when the nymphs migrate. Repeat the application in about 10 days to catch all nymphs.
	June beetle *(Phyllophaga* sp.*)* European chafer *(Rhizotrogus majalis)* **[Plate 17]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin T&O, 2.3–3.5 L Sevin 50 W, 2–3 kg	These beetle larvae are referred to as "white grubs." They chew fibrous roots and girdle underground stems of many woody ornamentals (including *Cornus* sp.). Cultivate infested fields before planting, to expose grubs to natural predators. Sevin T&O is registered as a foliar spray for adults. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	Juniper scale *(Carulaspis juniperi)* **[Plate 31]**	Diazinon 500 EC, 1.25 L insecticidal soap, see label Malathion 500 EC, 2.5 L Orthene 75 SP, 1 kg Sevin 50 W, 2–3 kg	This small, circular, white scale with a yellow centre causes juniper and arborvitae needles to turn yellow. Treat crawlers in late June when *Philadelphus* is at full bloom and *Catalpa* are beginning to bloom. Repeat as needed about 10 days later.

	Pest	Product/1,000 L Water	Notes
INSECTS	Spruce spider mite *(Oligonychus ununguis)* **[Plate 47]**	Cygon 480 E, 2 L Floramite SC, 625 mL horticultural oil, 20 L insecticidal soap, see label Kanemite 15 SC, 0.42–0.92 L Lagon 480, 2 L Landscape Oil Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375–500 mL Vendex 50 W, 0.5–1.0 kg	Overwintered eggs hatch in early May, when *Amelanchier laevis* and *Magnolia x soulangiana* are in full bloom. Mites prefer older needles as feeding sites. To monitor for mites, use a hand lens to check the undersides of twigs and needles for tiny reddish eggs or brown mites with black backs. Shake a branch over a white sheet of paper and look for crawling specks. Apply miticides when mites first appear. Kanemite is effective against motile life stages but may also reduce egg viability. Use horticultural oil as a dormant treatment in early spring to target eggs and newly hatched nymphs. DO NOT USE horticultural oil (including Landscape Oil) on white pine. Landscape Oil can be used when plants are dormant or in summer when leaves are fully expanded and hardened off. See product label. Permanent discolouration of foliage will occur to blue cultivars of both *Juniperus* and *Picea*. To prevent foliar discolouration on blue Colorado spruce, use only wettable powders and avoid horticultural oil. If populations are still significant, make two applications of other miticides at 10-day intervals when mites exist in spring. Many predatory mites co-exist with pest mite populations. To conserve predatory mites, try miticides that have less impact on these beneficials, such as Vendex and Floramite.
	Strawberry root weevil *(Otiorhynchus ovatus)* **[Plates 85 and 87]**	Pounce, see product label	The weevil larvae are small, white, legless grubs that eat fibrous roots or strip bark from larger roots. The reddish-brown flightless adult is under 6 mm long and is much smaller than the black vine weevil. Adults hide during the day and feed at night. Adults are active in late June and early July, when *Wiegela florida* and *Syringa reticulata* are blooming. Adults injure plants by puncturing and girdling the current season's shoots while feeding. These pests have a large host range. Commonly injured plants include white cedar, spruce and juniper. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. Adults play "dead" during daylight hours and feed at night. Pounce is registered for use on seedlings. To test treatment safety, treat some conifer seedlings, especially pine, before treating a larger area.
	Tarnished plant bug *(Lygus lineolaris)* **[Plate 86]**	Ripcord 400 EC, 172 mL/ha	This plant bug is a small, yellowish-brown insect with a five-sided "shield" appearance to the wings. Tarnished plant bugs feed by inserting their mouthparts inside leaf tissue and sucking out the contents, leaving the lower and upper epidermis behind. The resulting injury appears as small, clear "windows" on leaf tissue of broad-leaved plants. On conifers, feeding often causes terminal growth to yellow and become distorted and bushy. Treat in spring and early summer to manage populations of this insect.
DISEASES	Botrytis *(Botrytis cinerea)*	Rovral 50 WP, 1.2–2 kg/ha	During very humid conditions, a fuzzy grey growth develops on infected plant parts. Treat twigs and buds in spring before leaves develop. Treat conifer seedlings at the onset of botrytis. Remove all fading and diseased plant parts promptly, especially when wet weather is predicted. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Damping off, root rot and stem rot *(Phytophthora, Pythium)*	Subdue MAXX, 1.2 L/ha (drench)	*Pythium* and *Phytophthora* cause root and stem rots during conditions of high humidity and moisture (e.g., propagation). Protect healthy tissue with preventive fungicides or treat at the first sign of disease. Subdue MAXX can be used as a drench or a pre-incorporated treatment for media to help protect conifer seedlings and transplants from *Pythium* and *Phytophthora*. See product label.

THUJA — eastern white cedar, arborvitae *continued*

	Pest	Product/1,000 L Water	Notes
DISEASES	Leaf blight *(Didymascella thujina)*	Copper Spray, 4.0 kg Dithane M-45, 80 WP, 2.75–3.5 kg Manzate 200 DF, 2.75–3.50 kg	This leaf blight mainly attacks western red cedar *(Thuja plicata)*. Apply fungicides at 10–14 day intervals starting at bud break to protect new growth.

TILIA — linden, basswood

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphid (various)	Endeavor, 100–200 g Tristar 70 WSP, 3 solupaks Trounce, 50 L	Aphids are small, soft-bodied insects that suck plant sap. Feeding injury often causes distortion and weakens the plant. Apply insecticides at the first sign of aphids. Do not make more than three applications of Endeavor per year. Do not apply more than 3 kg of Endeavor per hectare per year.
	Fall cankerworm *(Alsophila pometaria)* **[Plate 38]** Spring cankerworm *(Paleacrita vernata)* **[Plate 39]**	Dipel 132 ES, 1.6–2.4 L/ha Orthene 75 SP, 1.0 kg	Green and dark grey inchworms (loopers, geometrids) can be found feeding on leaf undersides and edges in spring. Cankerworm can cause significant defoliation to deciduous trees. Treat with insecticides when larvae are small.
	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).

	Pest	Product/1,000 L Water	Notes
INSECTS	Japanese beetle *(Popillia japonica)* **[Plates 74 and 75]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin XLR PLUS, 2.3–3.5 L	The adult beetles are metallic green and copper, about 13 mm long. They are easily recognized by six tufts of white hair on each side of the abdomen. As the beetles feed, they consume and skeletonize foliage. Preferred hosts include members of the rosaceous family, maple, birch, linden and fruit trees. Spray adulticides when adults appear in early July, when the *Yucca filamentosa* is blooming. Larvae are C-shaped milky-white grubs about 25 mm long with brown heads and three pairs of legs. Japanese beetle larvae are distinguishable from other white grubs by a V-shaped arrangement of spines on the underside of the abdomen. Larvae are most commonly found feeding on the fibrous roots of turfgrass. Dursban T is a rescue treatment to allow shipping from infested to uninfested regions. Apply to soil when grubs are young and actively feeding near the soil surface. Apply as a coarse spray and irrigate with 1–2 cm of water to wash the insecticide into the underlying soil. For containerized stock, submerge the root ball into a solution of Dursban T (45 mL/10 L water) until all bubbling stops. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	Linden looper *(Erannis tiliaria)*	Malathion 500 EC, 2.5 L Sevin 50 W, 2.0–3.0 kg	Linden looper larvae are bright yellow with rusty-brown heads and 10 wavy black lines down the back. Larvae are present from early spring to early summer. This looper feeds on a wide variety of hardwood leaves. Band specimen trees with sticky trapping materials in late summer. This will trap wingless females as they climb up the trunk to lay their eggs. Treat foliage when larvae first appear.
	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of two times per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)

TSUGA — hemlock

	Pest	Product/1,000 L Water	Notes
INSECTS	Black vine weevil Taxus weevil *(Otiorhynchus sulcatus)* **[Plates 80 and 81]**	Nemasys G, BGreen, see label Sevin 50 W, 2.00–3.0 kg *Thiodan 4 EC, 1.25–1.75 L *Thionex 50 WP, 1.5 kg	The weevil larvae are small, white, legless grubs that eat fibrous roots or strip bark off larger roots. Infested plants grow slowly or fail to grow. They look dry and off-colour. Transplants often die without becoming established. Larvae control is difficult. Adults are black snout beetles that hide in soil litter during the day and cut crescent-shaped notches in needle margins at night. They also attack arborvitae, euonymus, yew, azaleas and rhododendrons. They can be a significant pest in container production. The beetles have fused wing covers and cannot fly. To control adults, treat foliage, trunk bark and branches during the last week of June and in early July. Spray in the evening, as adult activity increases about an hour after sunset. Do not use Thiodan on Anderson yew. To test treatment safety, treat some conifer seedlings, especially pine, before treating a larger area. Entomopathogenic nematodes (e.g., *Heterohabditis* sp.) are available to help suppress populations of larvae. Nematodes work very well in infested containers but with less success in the field. Nematodes can be applied in late summer/early autumn and in mid-spring to suppress larval populations. See product label for complete directions. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. ** Thiodan and Thionex are toxic to fish.*
	Eastern hemlock looper *(Lambdina fiscelleria)*	Foray 48 B, 2.5–3.1 L/ha Mimic 240 LV, 290 mL/ha	This looper is 3 cm long, greyish and flecked with black dots. It prefers hemlock, balsam fir and white spruce, but will feed on several other coniferous and broadleaf hosts. Apply Mimic to control early instar larvae. Allow 3–7 days for larval mortality. A second application of Mimic may be required.
	June beetle (*Phyllophaga* sp.) European chafer *(Rhizotrogus majalis)* **[Plate 17]**	**Larval management:** Dursban T, 4.5 L (rescue treatment for shipping) Intercept 60 WP, 467 g/ha **Adult management:** Imidan 50 WP, 1.25 kg Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L	These beetle larvae are referred to as "white grubs." They chew fibrous roots and girdle underground stems of many woody ornamentals (including *Cornus* sp.). Cultivate infested fields before planting, to expose grubs to natural predators. Sevin T&O is registered as a foliar spray for adults. Apply Intercept 60 WP once per year, during the mating period/egg-laying period and up to egg hatch (usually late June/early July in southern Ontario). In the field, sufficient irrigation (5–10 mm) should occur within 24 hours after application; avoid overwatering.
	Tarnished plant bug *(Lygus lineolaris)* **[Plate 86]**	Ripcord 400 EC, 172 mL/ha	This plant bug is a small, yellowish-brown insect with a five-sided "shield" appearance to the wings. Tarnished plant bugs feed by inserting their mouthparts inside leaf tissue and sucking out the contents, leaving the lower and upper epidermis behind. The resulting injury appears as small, clear "windows" on leaf tissue of broad-leaved plants. On conifers, feeding often causes terminal growth to yellow and become distorted and bushy. Treat in spring and early summer to manage populations of this insect.

ULMUS — elm

	Pest	Product/1,000 L Water	Notes
INSECTS	Aphids (various)	Endeavor, 100–200 g Tristar 70 WSP, 3 solupaks Trounce, 50 L	Aphids are small, soft-bodied insects that suck plant sap. Feeding injury often causes distortion and weakens the plant. Apply insecticides at the first sign of aphids. Do not use Orthene on American elm. Do not make more than three applications of Endeavor per year. Do not apply more than 3 kg of Endeavor per hectare per year.
	Elm bark beetle: European elm bark beetle *(Scolytus multistriatus)* Native elm bark beetle *(Hylurgopinus rufipes)* **[Plate 88]**	Pyrate 480 EC, 10 L	Elm bark beetles are vectors of the Dutch elm disease fungus. The smaller European elm bark beetle feeds in the crotches of small twigs. The native elm bark beetle attacks rough-barked branches and stems, causing distinct gallery formations. Both are small, brownish beetles about 3 mm long. Destroy elms infected with Dutch elm disease before overwintering adult beetles emerge and lay eggs. To control beetles, treat on suitable days in March and April, before leaves appear on the trees. Apply a second treatment in late July.
	Elm casebearer *(Coleophora ulmifoliella)*	Malathion 500 EC, 2.5 L Sevin 50 W, 2.0–3.0 kg	Overwintering casebearer larvae feed on emerging leaves. The larvae mine leaves. Heavy infestations cause leaf browning or scorching. All elms are potential hosts. Treat foliage in early June as mines begin to appear.
	Elm flea weevil *(Orchetes alni)* **[Plate 93]**		Adult beetles overwinter in leaf litter and become active as leaves start to emerge in early spring. Adult flea weevils are very tiny (2–3 mm) and brown with black spots on their back. Adults feed on new leaves, and injury ranges from small holes to skeletonized leaves. Adults lay eggs in leaf veins, and larvae hatch to feed inside leaf tissue as leafminers do. Larvae are very tiny, white and legless. The preferred host is Siberian elm *(Ulmus pumila)*.
	Elm leaf beetle *(Pyrrhalta luteola)*	Orthene 75 SP, 1.0 kg Sevin 50 W, 2–3 kg Success 480 SC, 25 mL *Thiodan 4 EC, 1.25–1.75 L	The adult beetle is olive-green with a dark stripe on each wing cover. The beetles chew holes in developing leaves, while the black larvae skeletonize the underside. They may attack all elm species. Treat the upper and lower leaf surfaces when they are about three-quarters expanded. Do not apply Orthene on American elm. ** Thiodan is toxic to fish.*
	Elm leafminer *(Fenusa ulmi)*	Safer's Insecticidal Soap, 1% solution Sevin 50 W, 2–3 kg	Treat foliage around late May to early June to control larvae as mines first become apparent. For small infestations, mined leaves can be picked off and destroyed. The adults are tiny, black sawflies that appear in early spring.
	European elm scale *(Gossyparia spuria)*	horticultural oil, see label insecticidal soap, see label Landscape Oil, see label	Overwintering scale nymphs become active in early spring. Crawlers are covered in white, waxy cottony strands. By June, females can easily be recognized by the white margins around the scale. Treat when young crawlers have emerged in early summer. Horticultural oils can be used when plants are dormant. Landscape Oil can be used when the plant is dormant or in the summer when leaves are fully expanded and hardened off. See the product label.

ULMUS — elm *continued*

	Pest	Product/1,000 L Water	Notes
INSECTS	European red mite *(Panonychus ulmi)*	Dyno-Mite, 284 g/ha horticultural oil, 20 L Landscape Oil, 20–30 L Malathion 500 EC, 1.25 L	These mites overwinter as eggs. Apply horticultural oils when plants are dormant or when they show 2.5 cm of green tissue and the flower buds are in a tight cluster.
	Fall cankerworm *(Alsophila pometaria)* **[Plate 38]** Spring cankerworm *(Paleacrita vernata)* **[Plate 39]**	Dipel 132 ES, 1.6–2.4 L/ha Orthene 75 SP, 1.0 kg	Green and dark-grey inchworms (loopers, geometrids) can be found feeding on leaf undersides and edges in spring. Cankerworm can cause significant defoliation to deciduous trees. Treat with insecticides when larvae are small. Do not use Orthene on American elm.
	Gypsy moth *(Lymantria dispar)* **[Plates 13 and 14]**	Dipel 132 ES, 1.6–2.4 L/ha Dragnet, 230 mL Foray 48 B, 1.0–1.6 L/ha Imidan 50 WP, 1.25 kg Orthene 75 SP, 850 g Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 L Success 480 SC, 25 mL Thuricide HPC, 1.6 L	Gypsy moth larvae are dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs but prefer basswood, birch, hawthorn, oak, poplar and willow. Adult females lay eggs in brown fuzzy masses in July and August. Remove and destroy egg masses before they hatch. Newly hatched larvae produce webs in order to disperse via wind to other hosts. Wait until larvae settle on hosts and begin feeding before applying Dipel or Foray. A folded burlap cloth wrapped around a tree provides a daytime shelter for larger larvae or pupae. Collect them from these shelters and destroy them. Orthene may damage sugar maple leaves. Success may be applied to larvae at any time during larval development. Dipel and Foray are most effective when sprayed before larvae become mature (before the head capsule turns yellow).
	Leafhopper (several species) **[Plate 41]**	Imidan 50 WP, 1.25 kg Sevin 50 W, 2.0 kg Sevin T&O, 2.3–3.5 L Tristar 70 WSP, 5 solupaks	Leafhoppers are tiny, yellowish-green to pale-coloured insects that jump quickly when disturbed. Wingless nymphs will often "side step" quickly to hide from potential predators. Leafhoppers have piercing-sucking mouthparts that cause yellowish flecks on the leaf surface. Check regularly for infestation of nursery crops when neighbouring farms are cutting alfalfa or hay. Hang yellow sticky traps in the canopy to monitor for leafhoppers. Check by disturbing plants or looking at the leaf bottoms for leafhopper nymphs or molted skins. Treat as required.
	Lecanium or European fruit lecanium *(Lecanium corni)* **[Plate 4]**	horticultural oil, 20 L insecticidal soap, see label Landscape Oil, 20–30 L Malathion 500 EC, 2.5 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 2.0 L Sevin 50 W, 2–3 kg Sevin T&O, 2.3–3.5 kg	This scale insect infests many deciduous trees and shrubs. When adults are mature in late spring/summer they appear as a large, reddish-brown, spherical scale usually found on the underside of twigs. Use horticultural oil as an early-spring dormant treatment to reduce populations of overwintering nymphs. Spray insecticides when the *Sambucus canadensis* begins blooming, to suppress crawlers. Do not use Malathion on Crimson King maple. Orthene may damage sugar maple leaves.

	Pest	Product/1,000 L Water	Notes
INSECTS	Two-spotted spider mite (TSSM) *(Tetranychus urticae)*	Apollo SC, 80 mL/ha Dyno-Mite, 284 g/ha Forbid, 300 mL insecticidal soap, see label Kanemite 15 SC, 2.1 L/ha Vendex 50 W, 0.5–1.0 kg	TSSM overwinters as adult mites in the soil or media around host plants. It becomes active during warm weather (late spring in the field). Attacked leaves become dull-coloured, stippled or bronzed. Check undersides of leaves for tiny mites and webs. These mites are very tiny; a hand lens will be needed to see the two faint black spots on their backs. Treat leaf undersides with miticides/insecticides when mites appear, and repeat as needed. Monitor for mites by examining lower leaf surfaces with a hand lens or vigorously shaking a branch over a sheet of white paper and looking for tiny, moving specks. Apollo SC acts primarily on mite eggs but has an effect on young motile stages as well. It is not effective against adult mites. Apollo SC should be applied when mite populations are predominantly in the egg stage, with few young motiles present. Do not make more than one application of Apollo SC per season. Apply Dyno-Mite when mites first appear. Apply Dyno-Mite a maximum of twice per season at an interval of 28 days apart. Apply Kanemite as mites appear. Kanemite may reduce the viability of eggs. (Two-spotted spider mite does not overwinter on the plant, and populations are not reduced with a dormant horticultural oil treatment.)
DISEASES	Dutch elm disease *(Ceratocystis ulmi)* *(Ophiostoma ulmi)* **[Plate 89]**	Arbotect 20-S, see product label	This disease often begins as the wilting of large branches, sometimes on one side of the tree. Leaves turn yellow and begin to flag or droop. Stripping away bark reveals stained wood. Control elm bark beetles that carry fungus from diseased trees to healthy ones. Remove diseased and dead materials to control the beetle populations that breed in them. Arbotect 20-S is a trunk-inject unit that introduces a fungicide into the plant system. Arbotect 20-S is registered for use by trained arborists or others trained in trunk injection techniques. This product may be effective when used where 1) 20% or less of canopy is showing wilt symptoms; 2) infested branches are removed at the first sign of wilt; 3) leaves have fully expanded and plant is actively transpiring (late May, June and early July).

VIBURNUM — virburnum

	Pest	Product/1,000 L Water	Notes
INSECTS	Snowball aphid *(Neoceruraphis viburnicola)*	insecticidal soap, see label Malathion 500 EC, 1.25 L Orthene 75 SP, 1.0 kg Pyrate 480 EC, 375 mL *Thiodan 4 EC, 1.25–1.75 L Tristar 70 WSP, 3 solupaks Trounce, 50 L	This aphid overwinters as eggs in *Viburnum opulus* buds. It does not seem to infest other species of *Viburnum*. Overwintering eggs hatch as buds begin to open in the spring. Feeding causes severe leaf distortion and twists young shoots. Treat foliage when aphids first appear (about mid-May) and repeat as needed. ** Thiodan is toxic to fish.*
	Viburnum crown borer *(Synanthedon viburni, S. fatifera)*		The larvae of this clearwing moth borer are cream coloured with a small brown head. They can be found boring in stems at the soil line (similar to peach tree borer). Signs of larval infestation include sawdust at the soil surface, disintegration of bark at the soil line, wilting and shrub dieback after it leafs out in spring. Remove and destroy infested plants before the larvae pupate (before mid-May). Pheromone traps are available to monitor for the adult stage of this pest.
	Viburnum leaf beetle *(Pyrrhalta viburni)* **[Plates 90, 91 and 92]**		Adults and larvae of this beetle skeletonize foliage of *Viburnum opulus*, European cranberry and its cultivars. Eggs overwinter in twigs of last year's growth. Larvae hatch and begin feeding as leaves emerge in the spring. Prune out and destroy terminal shoots (containing eggs) before May 1.
DISEASES	Downy mildew *(Peronospora viburni)*		Symptoms of this disease appear as angular lesions between leaf veins. The undersides of leaves turn woolly from fungal growth. Plants often defoliate in response to infection. Downy mildew needs moist conditions and cool or warm (not hot) temperatures. Do not crowd plants. Maintain adequate sunlight and good air circulation. Avoid overhead irrigation late in the day. Collect and destroy infected plant material.
	Powdery mildew *(Microsphaera sparsa)*	Daconil 2787 F, 2.5 L Daconil Ultrex, 1.5 kg	This fungus appears as a white, powdery growth on the tops of leaves. Apply fungicides at the first sign of disease. Do not crowd plants. Maintain adequate sunlight and good air circulation. Overhead watering during the day may reduce the spread and development of the disease. Avoid overhead irrigation late in the day. Apply fungicides when symptoms are first noticed, in mid-summer. Reapply at 5–10 day intervals.

5. Rodents and Deer

Rodents and deer can cause significant injuries to nursery and landscape plants. Controlling these pests can be difficult and often requires long-term strategies. For additional information, see the OMAFRA Factsheet *Rodent and Deer Control in the Orchard*, Order No. 98-023.

Vole Control

Voles and mice are common pests in agricultural production systems and around buildings. Voles can cause significant economic injury to nursery stock. They are most commonly a problem when there is a lack of food available. Voles are brown or grey rodents with stocky bodies and short legs. Unlike mice, they have a short tail and their ears lie flat against their body. Voles are active day and night, year-round. Females can start reproducing when they are just 3 weeks old. Voles chew on roots and girdle tree and shrub stems and trunks. There are two types of voles: pine voles and meadow voles (also known as "meadow mice" or "field mice"). The meadow vole is more common in Ontario.

Meadow voles make shallow runways along the soil surface. In spring and summer, they feed on grass seeds, herbs and bulbs. In fall and winter, they feed on the bark of woody plants. The feeding injury is more extensive in winters with continuous, prolonged snow cover. Pine voles burrow underground, feeding mainly on rootlets and stripping the bark off larger roots.

Vole Control Options

Voles need shelter, food and protection from predators to survive. Manage vole populations by eliminating one or more of these requirements.

In the landscape, maintain good weed control for a distance of at least 60 cm from tree trunks and shrub stems.

In a nursery with cover crops between tree rows, maintain a herbicide strip at least 1.2 m wide at the base of each tree. Mow the cover crop short in late summer, since dense stands provide shelter for rodents. Tree guards should extend at least 45 cm up the tree trunk. Anchor guards firmly into the soil, about 8 cm deep. Keep them secure and free from trash.

Where possible, encourage populations of natural predators such as hawks, owls, crows, ravens, weasels, foxes, coyotes, raccoons, skunks, cats and snakes that feed on voles. Predation may not manage high vole populations, but it may help to reduce populations in normal years.

Use mouse baits (rodenticides) where voles have caused damage in the past. Begin baiting the field border in early September to help prevent vole populations from exploding in autumn. Alternate between a zinc phosphide bait and an anticoagulant bait (see Table 5–1, *Rodenticides*, on page 160). Multiple applications of zinc phosphide are not recommended as voles can become bait shy after the first application and continue to avoid bait for 2–4 months.

Use bait stations to extend the life of the bait and create a safe haven for rodents to feed. Bait stations will also keep poisonous bait out of reach of pets and other non-target animals. The inverted T bait station is made of 1.5-inch (3.8 cm) ABS pipe and is probably the most effective type of bait station available. In this station, place several spoonfuls of bait in the neck, which is capped to protect the bait from the elements. Longer necks can be used in areas where there is substantial snowfall. Set about 25 stations/ha (10/acre). (In field production, baits can be broadcasted over infested areas on sunny fall days when no rain is expected.)

Precautions for Handling Poison Baits

It is important to handle poison baits safely. Consider the following points in order to help carry out a successful vole management program:

- The baits listed in Table 5–1, on page 160, are recommended for use with commercial nursery plantings only.
- Mark all poison bait storage containers POISON.

- Store poison baits away from children, pets and livestock.
- Do not inhale zinc phosphide dust or fumes.
- Do not keep baits containing zinc phosphide in a building used by people or animals.
- Do not use bait mixing or application equipment for any other purpose.
- Wear rubber or other protective gloves, as when handling hazardous insecticides.
- Wash after handling poison baits.
- Keep dogs and cats that are enthusiastic mousers away from the nursery for at least 2–3 days to prevent them from catching dying mice.
- Do not handle dead mice or voles with bare hands.
- Dispose of dead mice and voles away from human and animal contact.

Use Table 5–1 to select a suitable rodenticide for vole and mouse problems.

TABLE 5–1. Rodenticides

Many rodent baits are available in mountable mini-blocks and pellets.

Method of Action	Generic Name	Trade Name	Target Pests
Anticoagulant	brodifacoum	Ratak +	Norway rats, roof rats, house mice
	bromadiolone	Boot Hill, Maki	Norway rats, roof rats, house mice
	cellulose	Rode-trol	mice and rats
	chlorophacinone	Ground Force, Rozol	Norway rats, roof rats, house mice, meadow voles
	difethialone	Generation, Hombre	Norway rats, roof rats, house mice
	diphacinone	Ramik Brown, Ramik Green	mice and voles
Acute poison	zinc phosphide	many products available	meadow voles, deer mice, mice, Norway rats, roof rats

Rabbit Control

Rabbits feed on the bark, twigs and buds of many woody plants. They seem to prefer thinner-barked plants such as fruit trees, crabapple, flowering dogwood, sweetgum, holly, privet, pine, birch and young maple.

Rabbit Control Options

Fencing may provide control for smaller areas. Use 25 mm wire mesh fencing, staked every 2 m with sturdy posts. Secure the fence bottom in the ground. Rabbits will not burrow under the fence, but will squeeze through any opening they can find. Extend the fence at least 60 cm above the maximum snow level. Individual tree guards may also be used. Trap rabbits and remove them from the area. Encourage natural predators. Shooting rabbits can keep numbers low. Maintain this method of control all year round. Consult with local authorities regarding firearm bylaws and regulations.

Use rabbit repellents to discourage feeding. The rabbit repellent must have long-lasting adhesive qualities to be effective. Repellants must taste unpleasant to the rabbit or have an undesirable odour. Apply repellant on all plant parts that the rabbit can reach. Take into account the height added by deep snow. Chemical repellents consist of commercial thiram-based mixtures (e.g., Skoot) and ammonia fatty acid soaps (e.g., Hinder). Mix thiram-based repellents with white exterior latex paint for an effective repellent. Combine 400 g Thiram 75WP with 2 L of water. Slowly stir this mixture into 4 L of white exterior latex paint. Do not use oil-based paints because they are toxic to trees.

Deer Control

Deer feed on the buds, shoots and leaves of many woody plants. Feeding causes growth setback and poorly shaped plants. For more information on deer control, see OMAFRA Factsheet *Rodent and Deer Control in the Orchard*, Order No. 98-023.

Deer Control Options

To help keep deer out of production areas, erect fences around plants that are attractive to deer (e.g., yew, hemlock, rosaceous plants). Use wire mesh fencing at least 2.4 m high and support it with sturdy posts. Electric fences may provide some control. Where regulated hunting seasons, special hunts and other measures have not satisfactorily reduced deer damage, deer-removal permits may be issued to farmers to cull those deer that are causing significant crop damage. These permits are issued to farmers, or their agents, only after several conditions have been satisfied. Farmers wishing to obtain a deer-removal permit must first request a damage evaluation report from the Ministry of Natural Resources. These permits are a last resort.

Repellents may not be very effective against deer browsing. They need to be reapplied during the winter months. Thoroughly applied repellents may be successful when alternate food sources exist. When food is scarce, repellents may not work. Chemical repellents consist of commercial thiram-based mixtures (e.g., Skoot) and ammonia fatty acid soaps (e.g., Hinder). Replace these taste repellents every 3–4 weeks. Apply when no rain is forecast for 24 hours and temperatures range between 4°C–27°C. Apply to all susceptible plant parts. Spray the outer portions of trees and shrubs to a height of 2 m.

Odorous repellents may discourage deer from feeding. Odorous repellents include bloodmeal, moth flakes, perfumed soaps and human hair. Some research shows that soap bars hanging in the field discourage deer. Use small soap bars (e.g., those available from hotels). Any brand of soap can be used. Drill a hole in each bar of soap, leaving the wrapper in place. Hang the soap from a branch about 75 cm above the ground using a twist tie or string. Each bar of soap will protect a radius of about 1 m.

Bags of human hair may also deter deer, though this approach has had inconsistent results. Place two handfuls of human hair in some nylon stocking or a fine mesh bag. Hang the bags on outer tree branches or from the perimeter of the area that needs protection. Place the bags up to 90 cm apart and 75 cm above the ground. Keep the bags in place from mid-fall to early spring, replacing them monthly.

6. Weed Management

A weed management program combines cultural, mechanical and chemical methods appropriate to the situation. Effective weed management depends on weather conditions, soil type and the cropping history. Before attempting corrective action, identify problem weeds and learn about their growth habits. See OMAFRA Publication 505, *Ontario Weeds*, for help in identifying weeds.

In April 2009, the Ministry of Environment amended the *Pesticides Act* with the *Cosmetic Pesticides Ban Act*, 2008 and Ontario Regulation 63/09. Pesticides are now classified for sale and use under 11 different classes. Note that agriculture (including nursery production) is excepted. For more information on the legislation, see the Ministry of the Environment's website at www.ontario.ca/pesticideban.

Once the weed population has been assessed, minimize potential problems before planting. Eliminate possible weed sources and prevent weeds from establishing.

Weed Control Principles

Many weed problems can be avoided by using weed-free crop seeds and transplants and by preventing weeds from going to seed. Monitor weed growth in both crop areas and the surrounding non-crop areas. Soil conditions that enhance microbial activity are a strong defence against weeds. Practices that increase soil biological activity (i.e., bacteria, fungi, earthworms, insects) can reduce weed problems. Biological activity can increase crop vigour while making weed seeds decay faster in the soil.

Reducing Weeds Before Planting

Use Cover Crops for Weed Suppression

If a nursery field is removed from production, plant a cover crop or green manure crop before replanting the field. Ploughdown crops such as rye, red clover, buckwheat, sudan grass, millet and oilseed radish are typical cover crops. Cover crops suppress weed growth through crop competition and allelopathy (exuding chemicals to prevent weed seed germination). Cover crops also reduce wind erosion of the soil, and their residues increase soil organic matter. Improved soil tilth is quite evident in the first crop after a cover crop.

Controlling Perennial Weeds

Many perennial weeds can present problems for nursery crops. These weeds include quack grass, bindweed, vetch, wild grape, perennial nightshade, thistles, ground ivy, burdock, horsetail, toadflax, milkweed, asters, nut sedge, willow herb and goldenrod. Consider the following points:

- Always attempt to minimize (or eliminate) perennial weeds in the preplanting year.
- If necessary, apply a systemic herbicide, such as Roundup, to perennial weeds in the preplanting year. Follow directions on the product label and always use the recommended application rate for the weed in question. Apply herbicides at the proper stage of weed growth (e.g., just before bloom for most perennial broadleaf weeds) to achieve permanent control.
- It can be difficult to control perennial weeds among established plantings because of crop sensitivity to some herbicides and the inability to practise clean cultivatation in established nurseries.
- Repeated cultivation will control some perennial weeds, such as bindweed. Clean weed debris from the cultivator before entering weed-free soils.
- Use non-selective herbicides (such as Gramoxone and Roundup) before planting a green manure crop and before ploughing it under. Short-residual herbicides such as 2,4-D may be used with tolerant green manure crops. However, avoid herbicides that leave a soil residue in the planting year (e.g., Simadex).

Crop Rotation

Crop rotation is an important part of any long-term weed control strategy. After ploughing a cover crop,

it is best to replant the field with different nursery stock. For example, if the previous crop was conifers, plant deciduous stock. This permits a change in tillage methods, row widths, harvesting and herbicide selection. Crop rotation helps break weed cycles and minimizes weed population increases. Short rotations using several crops will increase the yield and profit of individual crops. Choose a crop that competes well with the problem weeds identified.

Stale Seedbeds

The stale seedbed technique involves preparing seedbeds early in the growing season. Allow the weeds to germinate. Several weeks later, control the weeds using glyphosate or paraquat. Once the weeds die, seed or transplant the crop into the bed, disturbing the soil as little as possible.

Preparing Container Beds

Prepare container bed areas with a gravel layer and/or ground coverings such as plastic, opaque woven materials. These surface coverings must exclude light to prevent weed-seed germination. Ground coverings may be reused for several years before it is necessary to replace them. Keep container beds and roadways weed-free by physical removal or chemical mowing. Remove all pulled weeds and discard them well away from the growing area. Do not allow seeds into nearby containers.

Remove existing weeds from container stock before they flower. Flowering weeds can disseminate hundreds of seeds by wind or by catapulting the seeds. Many container weed species have several generations per year since their seeds do not need to overwinter before germinating. Every fall, thoroughly remove weeds from container stock so they do not overwinter in the protected environment of the polyhouse. Be sure to remove the rosettes of winter annuals such as shepherd's-purse and Canada fleabane. Also remove the established plants and seedlings of common and mouse-eared chickweed. If not removed, these plants will flower by May or earlier.

Managing Weed Sources

Minimize weed sources using the following mechanical, cultural and/or chemical weed control measures:

- Control seed escapes using mechanical removal or chemical mowing before the weeds set seed.
- Prevent weeds from setting seed in adjacent non-cropped areas.
- Mow at regular intervals to prevent weeds from flowering.
- Use string trimmers in appropriate areas, such as along fences.
- Find the source of weeds that disseminate into the field or container yard. These include poplars, willows, willow herb and Canada fleabane.
- Control weeds around irrigation ponds to avoid sowing small-seeded weeds into container stock with each watering.
- A thick grass cover will help reduce weeds while stabilizing the bank.
- A filtering system in the irrigation line removes weed seeds.

Mechanical Weed Control

Mechanical weed control methods can reduce weeds and weed sources. Plant only weed-free seedlings and transplants. Do not bring weeds from one field to another. Keep equipment free from weed debris when moving it between fields. Cultivate weedy fields last.

Rotary Hoes

Rotary hoes have fingers that lift and mix the soil, uprooting small weeds. Rotary hoes tend to damage crops less than harrows do. The hoes break up soil crusts and incorporate surface-applied herbicides into the soil. This activates the chemicals and improves the weed control. Use rotary hoes during late-morning or afternoon hours. Crop plants are more pliable at these times, reducing injuries, and the hot sun can dry out the uprooted weeds.

For good results, maintain sufficient speed (generally 10–20 km/hr). Cultivating at slow speeds will

not generate enough force to lift weeds out of the ground, and it may cause more crop damage. On light soils or in loose soil conditions, keep rotary hoes shallow.

Inter-Row Cultivation

Inter-row cultivation or scuffling of row crops uproots small weeds and cuts off larger ones. Many kinds of equipment can perform this task. When using shovels, allow 50% overlap for thorough weed control. Keep the cultivation shallow and use shields to protect small crops. The first cultivation is crucial, since weeds escaping this pass usually grow to maturity. Row cultivation works well alongside herbicide applications. Shallow cultivation (2.5–5.0 cm) reduces the disturbance of any herbicides applied.

Mowing

Mowing and cutting help to control weeds. Mow perennial weeds at the bud stage, when root reserves are low and seeds have not set. If a herbicide is to be applied later in the season, allow enough time for weed regrowth after mowing.

Managing Herbicide Resistance

More than 120 herbicide-resistant weed species exist throughout the world. See the OMAFRA Factsheet *Herbicide Resistant Weeds*, Order No. 01-023 (available on the OMAFRA website at www.ontario.ca/crops) for a list of weeds that show resistance in Ontario. Herbicides should be used conservatively. Strategies for preventing the development of resistance should be used.

Delaying Herbicide Resistance

Repeated use of the same herbicide tends to create resistant weeds. Resistance develops at different rates with different herbicides, weed species and weed populations. To help minimize resistant weeds, follow these strategies.

Identify and monitor weeds. Resistant weeds look exactly like susceptible weeds except they escape the injury and mortality that happens to other members of the population. "Escapes" are common after herbicide applications. Sometimes 10%–30% of a weed population can become resistant before the issue is noticed. Survey fields regularly and apply diagnostic methods to catch problems as they arise.

Prevent weed spread. Clean all implements when leaving a field, and never allow resistant weeds to go to seed.

Use alternatives to chemical controls. Use mechanical weed controls, such as rotary hoeing or cultivation, wherever possible.

Rotate crops and herbicides. Do not use the same herbicides every year. Rotate crops and spray the new crop with herbicides from a different group (i.e., different mode of action or site of action) to prevent resistance. Where registered, use tank or formulated mixtures with multiple active ingredients that kill the same weed in different ways.

Keep records. Keep accurate records of crop rotation and herbicide usage for each field. Long-term weed control planning is easier with good records.

Communicate. Consult with farmer organizations, universities, extension specialists, agribusinesses, friends and neighbours about herbicide resistance problems. Inform the provincial weed inspector or industry contacts of any resistance issues that arise so they can act to prevent weed spread.

Diagnose. Weeds that survive a herbicide application may not be resistant. It is important to rule out other factors that can affect herbicide performance. Examples include misapplication, unfavourable weather conditions, improper application timing and weed flushes following a non-residual herbicide application. If resistance appears possible, check for the following:

- Did the product control other weeds listed on the label? Chances are only one weed species will prove herbicide resistant in a given field situation. If several normally susceptible weed species exist, other factors probably caused the lack of weed control.
- Did the same herbicide(s) from the same group with the same action site fail in the same field area last year?
- Were the same herbicide(s) from the same group used year after year?

If at least one of these situations applies, the weed escapes may be resistant to the herbicide. Try controlling the weeds with a herbicide from another group or use appropriate non-chemical weed control methods. Do not let the weeds go to seed. Contact the closest OMAFRA specialist, as well as the herbicide supplier and the appropriate chemical company, to develop a comprehensive management program.

Chemical Weed Control

Selective and non-selective herbicides may be used to control weeds. Use selective chemicals to control weeds among crops. Use non-selective chemicals to control perennial weeds or weeds on land not in crops such as roadsides, fencerows and areas that are difficult to cultivate. For a list of herbicides registered for weed management in nursery crops see Table 6–1, *Herbicides Registered for Nursery Crops in Ontario (by Trade Name)* on page 174 and Table 6–2, *Herbicides Registered for Nursery Crops in Ontario (by Common Name)* on page 174. For a list of herbicides registered for weed management in specific woody crops, see Table 6–3, *Herbicides Registered for Use on Woody Plants* on page 190.

Herbicide Licensing Requirements

An exterminator's licence is required to apply herbicides for commercial use. Any person operating an extermination business must hold an operator's license. For further information about pesticide licensing or to obtain an application package, please contact the Ministry of the Environment, Environmental Assessment and Approvals Branch:

Toronto: 416-314-8001

Toll Free: 1-800-461-6290

In April 2009, the Ministry of Environment amended the *Pesticides Act* with the *Cosmetic Pesticides Ban Act*, 2008 and Ontario Regulation 63/09. Pesticides are now classified for sale and use under 11 different classes. Note that agriculture (including nursery production) is excepted. There is also an exception for the use of pesticides to maintain the health of trees. For more information on the legislation, see the Ministry of the Environment's website at www.ontario.ca/pesticideban.

Applying Chemical Herbicides

To successfully control weeds, the correct amount of herbicide must be applied uniformly over the target area. While small areas can be treated with a garden sprayer or even a watering can, power equipment will be required for larger areas. Whatever application method is used, it is important to wet all weed foliage.

Herbicides are applied as emulsions, solutions or suspensions. The volume to apply per hectare depends on the herbicide used and the crop being treated. Generally, apply low volumes (50–200 L/ha) of postemergent chemicals on emerged weeds. Higher volumes (150–300 L/ha) are usually required for preemergent herbicides. Read the herbicide label and manufacturer's recommendations for the correct volume and pressure.

General Precautions

Selective weed control requires precision spraying equipment, expertly used.

Herbicide drift can damage nearby plants. High pressure, small nozzle tips, herbicide dusts and herbicide mists increase the risk of damage. Take all possible precautions to prevent drift from treated areas into non-target areas.

Never apply herbicides in enclosed structures (cold frames or greenhouses) unless the manufacturer specifically recommends this use.

Equipment used with 2,4-D-like chemicals must never be used to spray other solutions on 2,4-D-susceptible crops.

To minimize drift, do not apply herbicides using mist or air blast sprayers in agricultural areas of Ontario.

Herbicide Drift

Herbicides can drift away from the intended target, damaging neighbouring plants and crops and impacting the environment. Drift injuries depend on the extent of herbicide escape and the susceptibility of the crops or plants it reaches. High-pressure sprayers and windy conditions increase the danger of drift.

When spraying herbicides, always guard against physical spray drift and vapour drift. Physical spray drift occurs when wind carries spray particles away from the intended target areas. Vapour drift comes from herbicide evaporation or volatilization. Vapours can escape during application or from droplets deposited on plant or soil surfaces. In addition to causing damage, vaporization reduces herbicide effectiveness.

To minimize drift, do not spray in hot weather, windy weather or when humidity is low. Use low pressures, larger nozzles and a larger water volume. Since large droplets drift less than small ones, use the largest droplet size that gives the desired coverage and distribution. To choose nozzles that produce large droplets, follow these guidelines:

- a nozzle with a narrow spray angle produces large droplets
- a larger orifice produces larger droplets
- a lower operating pressure produces larger droplets

When to Use Herbicides

Apply herbicides when both crop resistance and weed susceptibility are high. The timing depends on the herbicide, the weeds to be managed and the crop. Several different terms describe when herbicides may be applied. Unless otherwise stated, these terms refer to the crop plant's development stage.

Application Technology

Always take care to apply herbicides correctly. Incorrect application can waste pesticide, compromise control, damage neighbouring crops and contaminate the environment. New equipment and control systems can make herbicide application simpler and more precise.

New Technologies

Equipment manufacturers now work closely with the crop protection industry to refine application systems. Computerized sprayer controllers and ground speed radar are available. These provide accurate monitoring and control during application. New developments in application technology include closed injection systems (which separate the herbicide concentrate from the water carrier) and drift reduction using air assists, air injection nozzles and electrostatic methods.

Sprayers for Small Areas

Use a 9–14 L knapsack or compressed air garden sprayer on small areas. A nozzle tip producing coarse spray minimizes spray drift. Keep spray pressure low. Although many smaller sprayers can create pressures up to 700 kPa, high pressures produce smaller spray droplets that can drift in light winds to susceptible garden plants. If the sprayer is to be used for herbicides, it should only be used for herbicides and not other types of pesticides.

To find out what products are excepted for use around the home in Ontario, check the Ministry of the Environment website at www.ontario.ca/pesticideban.

Field Sprayers

Use boom-type sprayers for field herbicide applications. These sprayers apply herbicide evenly across the width of the boom. Always maintain:

- uniform spray pressure
- constant forward speed
- stable boom height (to ensure uniform overlap of the nozzle tip patterns)
- an application rate of 55–450 L/ha

Air Blast or Mist Sprayers

Never use air blast or mist sprayers to apply herbicides. They can cause herbicidal drift damage far from the target treatment area.

Wiper Applicators for Selective Weed Control

Wiper applicators (e.g., rope-wick, roller applicator) are commonly used with glyphosate. Check the product labels for information about using this technique with other herbicides. Labels will list the crops for which wiper application is registered. To use wiper applicators, follow the manufacturer's directions. Contact enough of the target weed to maximize effectiveness of the herbicide. Keep the applicator tip above the desirable vegetation to avoid crop injury. Maintain a vehicle speed of 4–10 km/hr. Make a second pass, especially in heavy weed infestations or if using a higher vehicle speed. Avoid contact with sucker growth in orchards, vinelands and shelter belts.

Equipment Use and Care

Spraying Speeds

Uniform application rates require a constant forward speed whenever spray nozzles deliver liquid. If a tractor's driving wheels slip on the soil surface, the tractor's speedometer will not indicate a change in forward speed. To monitor forward speed despite wheel slippage on hills, use an independent speedometer with a ground-driven wheel. Install spray monitors and other electronic rate controllers. These automatically correct for tractor speed variations to maintain a constant application rate.

Using Water Correctly

Mix herbicides with clean water that does not contain debris, sand or mud. Never let the water intake screen rest on a pond bottom when filling a sprayer. The water intake line near the screen must, by law, have a check valve or backflow device. This prevents water-source contamination when the pump is shut off. Do not use a tank-refilling nozzle, volume-booster nozzle or injection pump when refilling sprayer tanks from ponds or streams. These tank-refilling aids may contaminate the water source. When using a farm water supply, install a frost-free water hydrant outside the building. Place a backflow valve/siphon on the discharge end of the hydrant.

Agitation

It is essential to return the spray solution to the sprayer tank to provide hydraulic agitation within the tank. To be effective, the return or bypass line from the pressure regulator must deliver liquid to the tank bottom. Return 2–14 L per minute to the tank when applying chemical formulations in solution. Return 14–27 L per minute for each 450 L of tank capacity when spraying wettable powders. The appropriate rate depends on the wettable powder concentration and the size of the tank. Wettable powders need a special line from the pressure side of the pump (not the pressure regulator) to the tank for adequate hydraulic agitation using a venturi jet or sparge tube. Sparge tubes need more water than venturis to provide the same agitation. Reduce the flow rate if the sprayer tank has a mechanical agitator.

Preparing a Wettable Powder and Oil or Emulsifiable Concentrate Mix

To prepare a tank mix of wettable powder and an oil or emulsifiable concentrate, follow these steps (unless the product label states differently):

1. Fill the sprayer tank with water to the half-full mark.
2. Start the agitator.
3. Add a premixed slurry of wettable powder and water.
4. Agitate for 2–3 minutes before adding more water.

5. Add the oil or emulsifiable concentrate last.
6. Do not over-agitate the mixture. It may become a grease-like mass that settles to the tank bottom. In addition, over-agitation may cause the mixture to foam excessively.
7. After any break from spraying, agitate the tank thoroughly before resuming.
8. To prevent oil build-up in the sprayer, empty the tank completely before refilling.
9. Clean the tank and sprayer with a detergent or solvent immediately after use, then flush thoroughly with clean water.

Pumps

Sprayer pumps must supply adequate capacity, pressure, volume and agitation for the task at hand. Use piston, diaphragm or centrifugal pumps for wettable powder suspensions. These, plus roller pumps, can be used for liquid herbicide applications. Pumps used for wettable powders and flowable formulations should have abrasion-resistant housings. For optimum pump performance, follow the manufacturer's care and storage instructions. Running a spray pump without water may cause premature wear or damage to the pump.

Nozzles

Accurate spray application requires high-quality nozzle tips. They must emit a uniform spray pattern at an expected rate. Machined orifice and moulded orifice tips are available in materials ranging from brass, stainless steel and hardened stainless steel to non-metals such as plastics/polymers and ceramics. Choose an appropriate tip based on the descriptions that follow, and examine the tip's spray pattern before each use. Maintain a stable boom height to ensure uniform spray pattern overlap and to avoid missing weeds in the target area.

All herbicide formulations cause orifice wear. This is especially true of wettable powders. Replace nozzle tips when they deliver 10% more spray than when they were new. Worn nozzle tips spray unevenly and can produce streaks across a field by delivering too much herbicide to a given area. Clean nozzle tips and screens thoroughly. Remove them from the nozzle body and wash them with soap, water and a bristle brush. Flushing water through the boom and nozzles will not remove pesticide residue build-up on the nozzles.

Flat-Fan Nozzle Tips

Flat-fan nozzle tips work well with boom-type herbicide sprayers. Flat-fan tips may be colour coded for size (i.e., output). Some colour-coded tips have stainless steel, ceramic or plastic/polymer inserts or are used for specialized applications. Always read manufacturers' labels carefully. Set spacings, boom height and pressure according to the manufacturer's recommendations. Unless the instructions state otherwise, maintain spray pressure at 275 kPa for standard elliptical-orifice flat-fan tips. Some flat-fan nozzle tips operate at a reduced pressure of approximately 140 kPa. These tips reduce the risk of drift.

Maintain a full overlap spray pattern by using 110-series flat-fan nozzle tips (instead of 80-series tips) with the same 51 cm spacing and the same height as the 80-series tips. This reduces misses in the event the boom bounces while crossing rough ground. Special "even spray" nozzle tips are available for herbicide band applications. The spray bandwidth is controlled by a combination of the nozzle's tip height, the spray angle and the orientation to the direction of travel. Follow the manufacturer's directions closely.

Flooding-Fan Nozzle Tips

Flooding-fan nozzle tips have a wide spray angle. They can be used closer to the ground and at lower pressures than flat-fan tips. This reduces drift. Flooding fan nozzle tips come in brass, plastic/polymers and stainless steel. They cover roughly twice the width as flat-fan nozzle tips. However, they tend to distribute herbicides less evenly than flat-fan tips.

Broadcast Nozzle Tips

Broadcast nozzle tips cover a very wide swath. Use broadcast nozzle tips for lanes and fence rows where a uniform spray pattern is not needed. Never use a broadcast-type nozzle tip near a susceptible crop. The spray may drift severely with even a light breeze.

Full and Hollow Cone Nozzle Tips

Use full or hollow cone nozzle tips to spray the soil surface when the herbicide is incorporated into the soil with a disk harrow, cultivator or similar tillage implement.

Nozzle Screens

Ball-check and plain nozzle screens are available. Ball-check screens use a diaphragm check valve on each nozzle to minimize dripping from the boom. Never mix screen types in a spray boom, since different screen types produce different flow rates through the nozzle. Always clean nozzle screens thoroughly. Using protective gloves, remove them from the nozzle body and wash them with soap, water and a bristle brush. Flushing water through the boom and nozzles will not remove pesticide residue build-up on the nozzle screens.

Cleaning the Sprayer

Consider the following recommendations when cleaning the sprayer:

- Clean sprayers immediately after spraying each day and whenever chemicals are changed. Delaying even overnight allows persistent deposits to form.
- Do not neglect any sprayer parts. Clean the spray tank, booms, hoses, nozzles, tips, screens, filters, strainers and pumps. Be sure to remove every trace of herbicide.
- Cleaning techniques depend on the herbicides applied. Many herbicides list tank-cleaning information on the label. Always follow these instructions. If necessary, contact the pesticide manufacturer to learn the best cleaning methods for a product. If specific cleaning instructions are not available, use a strong detergent or alkaline cleaner and then rinse thoroughly.
- Surfactants may remove some pesticide residues from spray equipment. Be sure tanks containing herbicide-surfactant (e.g., Agral 90) mixtures are scrupulously clean. Otherwise, the mixture may remove residues from the spray equipment, which may damage the crop.

Environmental Issues When Cleaning

Before cleaning the sprayer, dispose of any surplus tank mix safely. The Grower Pesticide Safety Course suggests diluting the remaining spray solution at least 1:10 with water. This diluted solution can be safely applied to the previously treated area if it does not exceed the maximum application rate on the product label. Equipment used with phenoxy herbicides (e.g., 2,4-D, MCPA) must never be used to spray other types of solutions on phenoxy-susceptible crops or garden plants. Never store these products near greenhouses or other areas with susceptible crops. The wash water contains herbicide. Never allow wash water into a well, lake, pond, river or other water source. For more information, see the pesticide application section of the OMAFRA website at www.ontario.ca/crops.

Sprayer Calibration

Calibrate sprayers frequently, especially when spraying wettable powders. Wettable powders erode the nozzle opening. As a nozzle wears, the quantity of herbicide delivered increases and distribution becomes uneven.

Determining Application Rates in L/ha

There are many ways to calibrate a sprayer or determine the amount of herbicide applied to 1 ha of land. Use one of the following two methods:

Method 1

This method requires a graduated cylinder calibrated in millilitres. See the OMAFRA website at www.ontario.ca/crops and click on the link to Pesticide Application and Safety for more detailed instructions.

1. Set two stakes 50 m apart in the field or along a fencerow beside the field.
2. Select the tractor gear and throttle setting that will be used while spraying. With the sprayer half full of water, do a test run to determine how many seconds it takes to travel the 50 m course. Repeat the trial at least three times to get an average time. Avoid previous wheel tracks in the field.

3. Mark or note the throttle setting and/or rpm's on the tachometer. Do not change the throttle setting when stopping for the next step.
4. Operate the sprayer while stationary. Use the desired pressure and the same throttle setting or rpm's used in the test runs. Spray for the length of time it took to travel 50 m. Collect the spray from each nozzle in a graduated cylinder.
5. Average the output per nozzle in millilitres. Clean or replace any nozzle more than 5% outside of the average nozzle output. Then reinstall all cleaned/new nozzles and recalibrate (repeat Steps 4 to 5).
6. Measure the boom's nozzle spacing in metres.

Application rate formula

$$\frac{\text{(mL of liquid per nozzle) x 0.2}}{\text{nozzle spacing (m)}} = \text{Application rate (L/ha)}$$

For conversions to litres/acre and gallons/acre, see Appendix E on page 201.

Sample Calculation:
Time to travel 50 metres: 24.5 seconds
Liquid collected/nozzle for 24 seconds: 525 mL
Nozzle spacing on the boom: 0.5 metres

$$\frac{\text{525 mL x 0.2}}{\text{0.5 m}} = \text{210 L/ha}$$

Method 2

1. Set two stakes 200 m apart in the field. Do not use a different distance. A different distance will not work, because this method divides the number of square metres in one hectare by the distance travelled as follows:

$$\frac{\text{10,000 m}^2\text{/ha}}{\text{200 m}} = \text{50 m/ha}$$

2. Add enough clean water to the sprayer to make the precalibration adjustments described in Steps 3 and 4.
3. Adjust the boom height to obtain the sprayer manufacturer's recommended overlap for the nozzle tips and nozzle spacing used. For example, for a spray angle of 65°, the boom should be 53–58 cm above the surface to be sprayed. For a spray angle of 80°, the height should be 42–48 cm above the target surface.
4. Operate the sprayer. Adjust the bypass relief valve to give the desired pressure with the nozzles operating. This also ensures that the sprayer lines are filled with water.
5. Fill the tank and place it on a level surface. Measure the water level using the tank's sight gauge or a measuring stick and record this number.
6. Spray between the stakes in one direction, maintaining a set speed and pressure. Turn the boom "on" as the tractor nose passes the first stake and "off" as it passes the second. Mark the throttle setting.
7. Return the sprayer to the same level location as before the calibration run. Refill the tank to the original mark on the sight gauge or measuring stick, carefully measuring the added water.
8. Calculate the application rate in litres per hectare using this formula:

$$\frac{\text{litres of water added x 50 m/ha}}{\text{swath width in metres}} = \text{L/ha}$$

Sample Calibration Calculations

Broadcast Spraying

If the sprayer's swath width is 6.5 m and it takes 30 L of water to refill the tank, the application rate in litres per hectare is:

$$\frac{\text{30 L x 50 m/ha}}{\text{6.5 m}} = \text{231 L/ha}$$

Band Spraying

With band spraying, acreage sprayed is not the same as crop acreage. The herbicide rates given in this publication apply to the area actually sprayed.

If the sprayer has 10 nozzles and each nozzle covers a 36 cm (0.36 m) band, the swath width is:

10 x 0.36 m	=	3.6 m

If it takes 10 L of water to refill the tank, the application rate in L/ha, using Method 2, is:

$$\frac{10\ \text{L} \times 50\ \text{m/ha}}{3.6\ \text{m}} = 139\ \text{L/ha}$$

Determining the Number of Hectares per Tankful

Once the sprayer has been calibrated, determine the number of hectares that can be sprayed with a full tank as follows:

$$\frac{\text{tank capacity (L)}}{\text{application rate (L/ha)}} = \text{ha/tank}$$

Sample Calculation

$$\frac{400\text{-litre tank}}{110\ \text{L/ha}} = 3.6\ \text{ha/tank}$$

For conversion between litres and gallons, see Appendix E on page 202.

Calibrating Hand-Held and Backpack Sprayers

Many people use small hand-held or backpack sprayers to treat problem areas or spray areas that were missed. Like field sprayers, small sprayers must be calibrated accurately.

Method 1

1. Set 2 stakes 50 m apart in the field.
2. Fill the sprayer half full with water.
3. Walk the 50 m course 3 times at a uniform pace. Calculate the average time to travel the course.
4. Measure the width (in metres) of the band sprayed by the nozzle at the same pace.
5. Pump the sprayer, collecting liquid from the nozzle into a measuring device for the average time calculated in Step 3.
6. Determine the application rate using the following formula:

$$\frac{(\text{mL liquid per nozzle}) \times 0.2}{\text{band width in metres}} = \text{L/ha}$$

Method 2

1. Partially fill the sprayer. Pump the sprayer to the pressure to be used during the pesticide application.
2. Spray to determine the swath width (in metres).
3. Walk at a steady pace for 15 seconds. Measure the distance travelled (in metres) during that time.
4. To calculate the number of square metres sprayed in 15 seconds, multiply the swath width (determined in Step 2) by the distance travelled (determined in Step 3). This area is A.
5. Spray into a measuring device for 15 seconds. The number of litres sprayed in 15 seconds is B.
6. Determine the application rate using the following formula:

$$\frac{B \times 1{,}000}{A} = \text{L/ha}$$

Conversion factors

Convert any pesticide application rate to the amount needed for a small area:

Solids:	1 kg/ha	=	10 g/100 m^2
Liquids:	100 L/ha	=	1 L/100 m^2

Determining the Herbicide Quantity Required

It's important to distinguish between the amount of product rquired and the amount of active ingredient required. The common name (i.e., its active ingredient) of each herbicide listed in this publication appears in lower case letters (e.g., napropamide, oxidiazon, glyphosate). The first letter of a product trade names is typically capitalized (e.g., Devrinol). However, in the Herbicide Compendium and tables that follow, they appear in all capital letters (e.g., DEVRINOL) for emphasis. Information on the total substance (e.g., liquid, powder) in the container is supplied

by the manufacturer. Its formulation appears in brackets following the trade name. Herbicides in this publication are specified by quantity of active ingredient (i.e., common name) per hectare and by quantity of product trade name per hectare. If the specified rate is "product per hectare," simply use that amount. Always verify product labels before use to confirm the amount of active ingredient it contains.

Materials, Mixing and Mixtures

Dry Formulations

Dry herbicide formulations come as granules, soluble powders and wettable powders. Granules do not require mixing; simply apply them as is. Many herbicides used for preemergent treatments come in granular formulations. Their performance usually equals that of the comparable liquid as long as the application equipment provides satisfactory distribution. Soluble powders should be dissolved in water. Wettable powders do not dissolve in water. They form a suspension that must be constantly agitated to keep it mixed.

Liquid Formulations

Many liquid herbicide formulations form a solution when mixed with water. Oil-based liquid herbicides form an emulsion that must be constantly agitated to keep it mixed. Emulsions appear milky.

Mixing Herbicide Formulations

Some herbicides can be combined with other chemicals in a single application. These combinations must be registered. Do not apply herbicide mixtures or herbicides mixed with other pesticides or foliar fertilizers unless the combination is registered for that specific use. Before mixing herbicides, consult package labels for compatibility information. Some combinations may react when mixed together, creating materials with new properties and activities. When using multiple herbicides together, mix one with the appropriate quantity of water. Then add the second. This reduces the formation of gums and precipitates that might clog nozzles and filters. Where water has a high salt content, test the compatibility of the water with the herbicide before spraying. Use the mixture at field strength in a small area and monitor the results. Do not use surfactants or detergents in spray solutions unless this is specifically recommended by the herbicide manufacturer.

Application Indicators

Colourants and foam markers are available from agricultural chemical dealers. These indicators make accurate applications easier. Foam marking systems help the applicator minimize overlap. Colourants added to a pesticide solution make the applied material more visible. For example, colouring a herbicide used on cut stumps of woody plants helps ensure thorough coverage without respraying, while water-soluble colourants make lawn spraying easier. Available colourants include:

- Bullsey Basal 55 Blue, oil soluble
- Blazon Blue, water soluble
- Bas-Oil Red, oil soluble

A Compendium of Herbicides with Their Recommended Uses in Ontario — 2009

Products appear alphabetically by common name below. Trade names listed under each common name appear alphabetically. All listed products are registered for the listed purpose. The order in which products appear does not constitute a preference ranking.

Classification of Pesticides for Sale and Use in Ontario

In April 2009, the Ministry of Environment amended the *Pesticides Act* with the *Cosmetic Pesticides Ban Act*, 2008 and Ontario Regulation 63/09. Pesticides are now classified for sale and use under 11 different classes. It should be noted that agriculture (including nursery production) is excepted. For more information on the legislation, see the Ministry of the Environment's website at www.ontario.ca/pesticideban.

TABLE 6–1. Herbicides Registered for Nursery Crops in Ontario (by Trade Name)

Trade Name	Common Name
AMITROL	amitrole
BASAMID	dazomet
BONANZA	trifluralin
CASORON	dichobenil
CIPC	chloropropham
DACTHAL	chlorthal dimethyl
DEVRINOL	napropamide
DUAL II MAGNUM	s-metolachlor
GALLERY	isoxaben
GRAMOXONE	paraquat
KERB	propyzamide
PRINCEP NINE-T	simazine
RIVAL	trifluralin
RONSTAR	oxadiazon
ROUNDUP	glyphosate
SIMADEX	simazine
TERR-O-GAS	methyl bromide/ chloropicrin
TREFLAN	trifluralin
VAPAM	metam sodium
Various products	glyphosate
VENTURE L	fluazifop-p-butyl

TABLE 6–2. Herbicides Registered for Nursery Crops in Ontario (by Common Name)

Common Name	Trade Name
amitrole	AMITROL
chloropropham	CIPC
chlorthal dimethyl	DACTHAL
dazomet	BASAMID
dichobenil	CASORON
fluazifop-p-butyl	VENTURE L
glyphosate	Various products (including ROUNDUP)
isoxaben	GALLERY
metam sodium	VAPAM
methyl bromide/ chloropicrin	TERR-O-GAS
napropamide	DEVRINOL
oxadiazon	RONSTAR
paraquat	GRAMOXONE
propyzamide	KERB
s-metolachlor	DUAL II MAGNUM
simazine	PRINCEP NINE-T SIMADEX
trifluralin	BONANZA RIVAL TREFLAN

Notes on Herbicides

These notes are listed below as a reference for applicators. Complete information on each herbicide is available on the product label located on the herbicide container. The federal Pest Management Regulatory Agency also provides pesticide labels under their "Quick Links" section at www.pmra-arla.gc.ca. Many herbicide manufacturers also list product labels and/or Material Safety Data Sheets (MSDS) on their websites. For a list of herbicides registered on nursery crops in Ontario, see Table 6–1, *Herbicides Registered for Nursery Crops in Ontario (by Trade Name)* on page 174 and Table 6–2, *Herbicides Registered for Nursery Crops in Ontario (by Common Name)* on page 174. For ratings of weed susceptibility to herbicides, see Table 6–4, *Weed Susceptibility and Herbicides — Broadleaf Annuals* on page 192, Table 6–5, *Weed Susceptibility and Herbicides — Broadleaf Perennials* on page 193 and Table 6–6, *Weed Susceptibility and Herbicides — Annual Grasses* on page 194.

PREPLANTING TREATMENTS

Some preplant herbicides act on germinating seedlings, while others kill weed seeds in addition to seedlings. Apply preplant herbicide treatments before sowing or planting the crop. Incorporate preplanting herbicides (e.g., Treflan) into the soil soon after application. Incorporation instructions are provided on the label.

Soil Fumigants

Fumigants generally control nematodes and soil diseases. At higher application rates, they can also control weeds.

Before applying fumigants for nematode control, have the soil tested for nematode count. See Appendix D, *Diagnostic Service*, on page 198, for sampling instructions. Ensure that nematodes are the problem before using chemicals. Carefully follow the fumigant manufacturer's directions for dosage and methods of use. Wear a suitable respirator and full protective gear when using fumigants. Telone, Vapam, Vorlex and methyl bromide are extremely toxic to the applicator. See Chapter 2, *Safe Use of Pesticides*, for safety details.

To use preplant fumigants effectively:

- Fumigate in the fall when soil temperatures are above 4°C. Fumigant dispersal improves at warmer soil temperatures (above 15°C).
- Remove trash and old root systems.
- Work the soil to a depth of 25–30 cm. Tilth and moisture should be in good seedbed condition.
- Inject the fumigant about 30–40 cm deep.
- Pack or water immediately after injection to seal the soil surface.
- Ideally, leave the soil undisturbed until spring. If fall planting is necessary, delay it until at least one week after the fumigant injection.
- Work and aerate the soil for about a week before planting. Colder soils (below 15°C) require longer periods from injection to aeration. For fall planting, aerate the soil for at least 2 weeks after working.
- Fall ryegrass has been recently linked with high populations of root lesion nematodes. To avoid this problem, try using non-traditional types of annual cover crops such as pearl millet and sorghum. Italian ryegrass may also be an option because it is a poor host for root lesion nematode.

The following chemicals may be used as preplant treatments.

Common Name:	**dazomet**
Trade Name:	**BASAMID**
Chemical Family:	**dithiocarbamate**

Rates of Application

dazomet	500.0 kg/ha
BASAMID (98 Gr)	510.0 kg/ha

Sensitive Weeds

Most germinating weed seeds.

Uptake and Translocation

Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds.

Basis of Selectivity

Non-selective. Chemical must dissipate completely from the seedbed before planting; otherwise, crop injury may occur.

Application Methods

Apply granular product to a well-worked seedbed and incorporate evenly. Seal soil immediately after incorporation by rolling and flooding or by covering with heavy polyethylene plastic and sealing the edges. After waiting 10–40 days, depending on soil temperature, aerate the soil. Conduct a safety germination test before using treated soil. Do not use when soil temperature is below 6°C. See the manufacturer's directions for specific details and directions on sealing soil, evacuating gases and performing the safety germination test.

Residual Activity

Depends on the rate applied, soil moisture and soil temperature. The gases are toxic to all growing plants. Perform a safety germination test before planting.

Unique Characteristics

Also controls unencysted nematodes and soil fungi.

Manufacturer: Mitsui & Co. (Canada) Ltd.

Common Name: metam sodium

Trade Name: VAPAM

Chemical Family: thiocarbamate

Rates of Application

metam sodium	1,250.0 kg/ha
VAPAM (380 g/L)	3,287.5 L/ha

Remarks

Use on field replant sites of ornamentals and forest tree stock.

Sensitive Weeds

Most scarified weed seeds and fleshy vegetative parts, including rhizomes and germinating seedlings.

Basis of Selectivity

Most plant parts are sensitive. Do not plant crops until all fumigant dissipates from the soil. When moisture is present, Vapam releases methyl isothiocyanate gas. This kills most scarified seeds and fleshy vegetative parts (including rhizomes and germinating seedlings).

Application Methods

Apply as a drench to soil, wetting at least 8 cm deep. Apply uniformly using injectors, water or other incorporation tools that carry the product to the desired depth. It may be applied via the irrigation system. No gas-proof cover is needed, unless the soil is very porous. Apply water via sprinklers to provide a surface water seal. Do not plant for 10–14 days (or longer if the weather is cool). To prevent crop injury, make sure all traces of toxic gas have dissipated from the treated soil before planting crops.

Residual Activity

10 to 40 days of residual activity can be expected, depending on soil temperature and the amount of organic matter in the soil. Vapam persists longer if temperatures are low or organic matter levels are high. Plant 12–16 days after treatment following a lettuce seedling bioassay that indicates no injury.

Unique Characteristics

Also controls nematodes, soil fungi and soil insects.

Manufacturer: Amvac Chemical Corp.

Common Name: methyl bromide/ chloropicrin

Trade Name: TERR-O-GAS 67

Chemical Family: organohalogen

Remarks

Methyl bromide is very poisonous to humans and livestock. Only experienced, licensed operators may use it.

Sensitive Weeds

Methyl bromide gas is toxic to germinating seedlings.

Application Methods

Methyl bromide is formulated as a pressurized liquid that, when released from its container, forms a gas. The product must be applied under a gas-proof cover, usually one made of plastic. The soil must be sealed with a plastic sheet since the gas is highly volatile. See the label for detailed directions.

Methyl bromide gas is very volatile and highly poisonous to humans and livestock. It can be absorbed through inhalation, ingestion and dermal contact. A permit from the Ontario Ministry of the Environment is required each time it is used.

The seedbed or greenhouse must be aired completely after the treatment period. If there is any question, study the safety precautions in the *Pesticides Act* and follow the manufacturer's directions to the letter.

Unique Characteristics

Also controls soil insects, nematodes and fungal diseases.

Manufacturer: Great Lakes Chemical Corp.

PREEMERGENCE TREATMENTS

Some preemergence treatment chemicals control weeds by killing weed seedlings. Others function as a toxic chemical layer (in which germinating seeds and young seedlings cannot survive) on or near the soil surface. A herbicide may have either or both effects on a target weed.

- Apply preemergence treatments either after the seedling stage but before the specified weed or crop emerges, or after planting new nursery stock.
- To avoid damage, make sure the crops tolerate the chemical at the seedling stage or the chemical's toxicity will have disappeared before the crop emerges.
- For best results, apply the treatment to a smooth, well-prepared, clod-free seedbed.
- The surface soil should be moist and the temperature favourable for rapid weed-seed germination.

The following chemicals may be used as preemergence treatments.

Common Name: chlorthal dimethyl

Trade Name: DACTHAL W-75

Chemical Family: phthalate

Site of Action: Group 3

Rates of Application

Field applications

chlorthal dimethyl	5.02-16.88 kg/ha
DACTHAL	6.75–22.5 kg/ha

Remarks

Use on established nursery stock: abelia, alyssum, baby's breath, barberry, candytuft, deutzia, English ivy, euonymus, feverfew, forsythia, gladiolus, holly, juniper, locust, maple, marigold, oak, peony, petunia, salvia, spiraea, sycamore, tulip tree, walnut, weigela, willow and yew. Can also be used on established ornamental plantings (e.g., flower gardens).

Do not use on bugleweed, button pink, carnation, celosia, germander, geum, mesembryanthemum, pansy, phlox, snapdragon, sweet William, telanthera or vinca minor.

Sensitive Weeds

Carpetweed, common chickweed, common lamb's-quarters, green foxtail, groundcherry, large crabgrass, lovegrass, purslane, redroot pigweed, smooth crabgrass, witch grass and yellow foxtail.

Uptake and Translocation

Absorbed by roots, not foliage. Not translocated through the plant.

Basis of Selectivity

Inhibits growth of germinating seeds.

Application Methods

Must be applied before weed seed germination. Rain or irrigation is needed for activation. Remove all existing weeds before application, as only germinating weeds will be controlled.

Residual Activity

Average half-life is 100 days in most soil types. Effective weed control can be maintained for as long as 2 months.

Manufacturer: AMVAC Chemical Corporation

Common Name:	**dichlobenil**
Trade Name:	**CASORON G-4**
Chemical Family:	**benzonitrile**
Site of Action:	**Group 20**

Rates of Application

Field applications	
dichlobenil	4.4–7 kg/ha
CASORON (4 Gr)	110–175 kg/ha
Container applications	
dichlobenil	4.4 kg/ha
CASORON (4 Gr)	110 kg/ha
Container bed preparation	
dichlobenil	4.4–7 kg/ha
CASORON (4 Gr)	110–175 kg/ha

Remarks

Use on field woody nursery stock: ash, birch (cutleaf weeping), boxwood, caragana, crabapple, eastern red cedar, eastern white cedar (arborvitae), elm, euonymus, forsythia, heather, holly (*Ilex* sp., except *I. crenata, I. rotunda, I. vomitoria*), honeysuckle, juniper, lilac, linden, locust, maple, mock orange, rhododendron, rose, spirea, willow and yew.

Use on some container woody nursery stock: *Juniperus chinensis, J. horizontalis* and *Thuja occidentalis* only.

Do not use on: ajuga, fir *(Abies* sp.), gladiolus, hemlock, *Ilex crenata, I. rotunda, I. vomitoria,* mugho pine or spruce.

Do not use on: herbaceous perennials (all plants that die down to the ground in the fall).

Use cautiously on: shallow-rooted ground covers (euonymus can be treated with this product).

Sensitive Weeds

Most weeds are susceptible to, or suppressed by, dichlobenil, including perennials, vetch and horsetail.

Uptake and Translocation

Absorbed by roots and rapidly translocated upward in the plant.

Basis of Selectivity

Selectivity is based on the physical separation between the dichlobenil vapour layer in the top 5 cm of soil and the established crop roots below this level.

Application Methods

Apply as a preemergence treatment to susceptible weeds, preferably in the fall or early spring. Apply to cool, moist soil.

Container nursery stock: Use only on containers growing outside. Apply at least 4 weeks after planting into containers with a weed-free surface. Do not use after September 15 or within 30 days of placing treated stock in overwintering structures.

Container bed preparation: Apply to bare soil before putting container pots onto the bed. For best results, apply to soils containing more than 2% organic matter. Dichlobenil provides inconsistent weed control on gravel or sandy soils. Apply in spring on a cool day and incorporate immediately using irrigation or mechanical methods. Do not cover polyhouses with plastic for 1 month after application. Do not apply in plastic-covered polyhouses or greenhouses. Do not transplant seedlings into treated soils until at least 1 year after application.

Residual Activity

May persist and provide weed control for 2–6 months. Higher rates and applications following use in previous years may cause soil residues to persist for more than 1 year.

Unique Characteristics

Although applied as a granular herbicide, it kills with a vapour layer in the topsoil profile. Weed roots take up the herbicide when entering this zone. Do not apply to very warm soils, since high temperatures volatilize the herbicide and prevent weed control.

Manufacturer: Chemtura Canada Co.

Common Name:	**flumioxazin**
Trade Name:	**BROADSTAR G** **SUREGUARD WDG**
Chemical Family:	**N-phenylphthalimide derivative**
Site of Action:	**Group 14**

Rates of Application

Field applications	
flumioxazin	143–215 g/ha
SUREGUARD WDG	280–420 g/ha
Container applications	
flumioxazin	0.21–0.42 kg/ha
BROADSTAR G	84–168 kg/ha

Remarks

Use BroadStar granular herbicide for preemergent weed control on outdoor container-grown woody ornamentals. Apply BroadStar herbicide before germination of target weeds or immediately after disturbing the soil surface. BroadStar herbicide can be safely applied over the top of many species of woody ornamental shrubs and trees providing the user follows the label directions. Apply to dry foliage only. Do not apply more than twice in a single year. See product label for more information. Use BroadStar on: *Acer ginnala, Acer palmatum, Buxus sempervirens, Juniperus horizontalis, Juniperus sabina, Picea pungens, Picea glauca, Quercus rubra, Taxus x media, Thuja occidentalis.*

Use SureGuard herbicide for preemergent weed control in field-grown ornamental deciduous and coniferous trees, including Christmas trees and trees produced for reforestation, and to maintain bare-ground non-crop areas in and around ornamental nurseries and field-grown ornamentals. SureGuard herbicide should be applied to tilled, weed-free and deciduous tree plantings. The deciduous trees species listed in the "Tolerant Deciduous Trees" section on the label have shown tolerance to applications of SureGuard herbicide only when applied to the soil and base of the plant. Tolerant ornamentals include: *Abies balsamea, Abies fraseri, Acer ginnala, Fraxinus pennsylvanica, Picea pungens, Pseudotsuga menzesii, Syringa reticulata* and *Thuja occidentalis.*

Do not use BroadStar on annual bedding plants and herbaceous perennials (e.g., hosta and daylily).

Do not use Broadstar on *Buddleia davidii, Clethra alnifolia, Deutzia gracilus* 'Nikko', *Hydrangea* spp., *Ilex verticillata, Myrica cerifera, Nandina domestica* 'Firepower', *Plumbago auriculata, Rhododendron* 'Delaware Valley', *Rosa* spp., *Spiraea japonica* or *Syringa* spp.

BroadStar herbicide can injure liners of several woody ornamental species that are tolerant when more mature.

Sensitive Weeds

Common lamb's-quarters *(Chenopodium album)*, common ragweed *(Ambrosia artemisiifolia)*, dandelion *(Taraxacum officinale)*, eastern black nightshade *(Solanum ptycanthum)*, green foxtail *(Setaria viridis)*, green pigweed *(Amaranthus powellii)*, hairy bittercress/snapweed *(Cardamine hirsuta)*, hairy nightshade *(Solanum sarachoides)*, liverwort *(Marchantia polymorpha)*, redroot pigweed *(Amaranthus retroflexus)*.

Suppression only: common chickweed *(Stellaria media)*, common groundsel *(Senecio vulgaris)*.

Uptake and Translocation

Root and shoot uptake.

Basis of Selectivity

BroadStar herbicide controls weeds by inhibiting protoporphyrinogen oxidase, an essential enzyme required by plants for chlorophyll biosynthesis. Seedling weeds are controlled preemergence when exposed to sunlight following contact with the soil-applied herbicide. BroadStar herbicide is tightly bound to soil and does not inhibit or limit root growth under normal growing conditions.

Application Methods

Container-grown ornamentals: BroadStar herbicide can be safely applied over the top of many species of woody ornamental shrubs and trees, providing the user follows the label directions. BroadStar herbicide should be applied over dry foliage. See product label.

Field-grown coniferous trees: All over-the-top applications of SureGuard herbicide should be

applied before bud swell in the spring or delayed until coniferous trees have sufficiently hardened off in the fall. For non-dormant coniferous ornamentals, applications may be made using a directed hooded or shielded spray.

Field-grown deciduous trees: For maximum safety to deciduous trees, directed applications of SureGuard herbicide should be made to the soil surface before bud swell in the spring or after dormancy has initiated in the fall. Direct the application of SureGuard herbicide to the soil surface and away from plant material.

Do not make more than 2 applications of SureGuard per season, and wait 8 weeks between applications.

Special Recommendations, Cautions or Restrictions

Apply BroadStar herbicide before weed seeds germinate. Disturbing the soil surface after application may reduce herbicide efficacy. Remove existing weeds, weed residues and trash before applying BroadStar herbicide. Apply to dry foliage only. To test for moisture, rub hands over plant foliage. Approximately 1–2 cm of rainfall, overhead sprinkler irrigation or hand irrigation is required to activate BroadStar herbicide. Irrigate plants within one hour after application with 1–2 cm of water to wash the particles off the plant foliage. Inadequate irrigation or rainfall following application may reduce the effectiveness of BroadStar herbicide. Drip irrigation cannot be relied on to activate BroadStar herbicide. If adequate soil moisture is maintained following application, BroadStar herbicide will provide residual control of the listed weeds, except under unusual environmental conditions (excessive rainfall, irrigation or temperature).

SureGuard herbicide may be applied to established field-grown deciduous trees. Preemergence applications of SureGuard herbicide should be made to tilled, weed-free deciduous tree plantings.

For maximum safety to deciduous trees, directed applications of SureGuard herbicide should be made to the soil surface before bud swell in the spring or after dormancy has begun in the fall. Direct the application of SureGuard herbicide to the soil surface and away from plant material. Avoid direct spray onto plant surfaces, flowers, foliage and green bark. SureGuard herbicide applications made after bud swell may result in plant injury if the herbicide contacts the tree foliage. Splashing of herbicide-treated soil onto foliage can result in plant injury and should be avoided. Do not apply to trees that have been established for less than 1 year, unless they are protected from spray contact by non-porous wraps, grow tubes or waxed containers. Newly established or transplanted trees should be sufficiently watered-in before application to settle soil around the plant.

Moisture is necessary to activate SureGuard herbicide in soil for residual weed control. Dry weather following applications of SureGuard herbicide may reduce effectiveness. However, when adequate moisture is received after dry conditions, SureGuard herbicide will control susceptible germinating weeds. SureGuard herbicide may not control weeds that germinate after application but before an activating rainfall or irrigation or weeds that germinate through cracks resulting from dry soil.

Residual Activity

The length of residual control depends on the application rate as well as on rainfall and temperature conditions. Length of residual control will decrease as temperature and precipitation increase. It will also decrease when there are high levels of organic matter and/or clay in the soil.

Manufacturer: Valent Canada Inc.

Common Name:	**isoxaben**
Trade Name:	**GALLERY 75 DF**
Chemical Family:	**benzamide**
Site of Action:	**unknown**

Rates of Application

Isoxaben	0.75 kg/ha
GALLERY 75 DF	1.0 kg/ha

Remarks

To be used on bareroot and container-grown nursery stock grown for silvicultural purposes. Use on the following nursery stock 4 weeks after germination or crop emergence: *Picea abies, Picea glauca, Picea mariana, Pinus banksiana, Pinus contorta, Pinus resinosa, Pinus strobus.* Do not use on cutflowers. Germination of some sensitive crop species may be reduced in the year following treatment. Gallery is labelled for use on several container-grown ornamentals: *Acer, Clematis, Cornus, Euonymus, Hemerocallis, Heuchera, Hosta, Juniperus, Picea, Potentilla, Prunus, Pseudotsuga, Rhododendron, Rosa, Spiraea, Taxus and Thuja.* Gallery is UV-sensitive.

Sensitive Weeds

Common lamb's-quarters, common purslane, low cudweed, pineappleweed, purslane speedwell, shepherd's-purse, St. John's wort.

Uptake and Translocation

Absorbed by roots and translocated to the shoots of germinating weeds.

Basis of Selectivity

Root selectivity.

Application Methods

Do not use more than once per season. Apply in late summer to early fall, early spring or any time before germination of target weeds or immediately after cultivation. A single rainfall or sprinkler irrigation of 1 cm after application is necessary to activate Gallery 75 DF within 21 days after application. Apply Gallery 75 DF in 100–400 L of water carrier per hectare.

Residual Activity

Provides season-long control.

Manufacturer: Dow AgroSciences

Common Name:	**napropamide**
Trade Name:	**DEVRINOL 2G** **DEVRINOL 10G** **DEVRINOL 50 DF**
Chemical Family:	**amide**
Site of Action:	**Group 15**

Rates of Application

napropamide	4.5 kg/ha
DEVRINOL 2G	225 kg/ha
DEVRINOL 10G (10 Gr)	45 kg/ha
DEVRINOL 50DF (50 DF)	9 kg/ha

Remarks

Use on: newly transplanted or established ornamentals, woody nursery stock, forest tree stock and container-grown ornamentals. DO NOT apply to species right after direct seeding. Devrinol is UV-sensitive.

Use on all of the following field-grown nursery stock:

Deciduous and evergreen trees: apple, ash, azalea, birch, black walnut, boxwood, cedar, cherry, cypress, dogwood, Douglas fir, eucalyptus, euonymus, fir, firethorn, hawthorn, hemlock, hibiscus, holly, honeylocust, hypericum, Japanese larch, juniper, laburnum, maple, peach, pear, pin oak, pine, plum, poplar, privet, rhododendron, rose, spruce and yew

Deciduous and evergreen shrubs: abelia, aucuba, azalea, bottlebrush, camellia, cotoneaster, crape myrtle, dogwood, forsythia, honeysuckle, leucothoe, nandina, osmanthus, photinia, raphiolepis, star jasmine and viburnum

Fruit and nuts: filbert, grape and walnut

Ground covers: ajuga, hedera, hypericum, ivy, lantana, liriope, pachysandra, sedum and vinca

Flowers: aster, dahlia, daisy, geranium, hosta, narcissus, osteospermum (African daisy) and petunia

Use on the following container-grown nursery stock: abelia, ageratum, azalea, bottlebrush, bougainvillea, boxwood, camellia, cedar, cotoneaster,

crape myrtle, cypress, dogwood, Douglas fir, English ivy, eucalyptus, euonymus, fir, firethorn, forsythia, gardenia, geranium, heather, hibiscus, holly, juniper, leucothoe, liriope, nandina, pachysandra, photinia, pine, privet, raphoiolepis, rhododendron, rose, sedum, star jasmine and vinca.

Sensitive Weeds

Many annual weeds including annual bluegrass, barnyard grass, chickweed, crabgrass, foxtail, goose grass, groundsel, lamb's-quarters, pineappleweed, prickly lettuce, prostrate knotweed, purslane, redroot pigweed, sandbur and wild oats.

Uptake and Translocation

Absorbed through the roots of germinating weeds. Translocated upward through seedlings.

Basis of Selectivity

Metabolized by tolerant species. Inhibits root growth of germinating seedlings. Does not affect established plants due to placement selectivity.

Application Methods

Field nursery stock: Apply herbicide before planting using water as the carrier. Incorporate uniformly to a depth of 2.5–5 cm, using irrigation or mechanical methods (e.g., tandem discs, field cultivator with sweep teeth). Follow with a levelling device.

Apply on established crops to a weed-free soil surface. Irrigate unless there is adequate rainfall within 7 days after spring/fall application or within 2 days after summer application. Soil must be wet to a depth of 5–10 cm.

Container nursery stock: Apply at any time of the year to a weed-free media surface. May be used on newly planted container stock once potting media settles after first watering. Incorporate by watering within 7 days after a spring or fall application. Water within 2 days after a summer application. Does not control bittercress.

Residual Activity

Provides season-long weed control if properly incorporated. Deep ploughing minimizes carry-over effects.

Unique Characteristics

Does not control germinated weeds. Resists leaching. To avoid crop injury, do not plant crops not registered for product use for 12 months after a napropamide application.

Manufacturer: United Phosphorus Inc.

Common Name:	**oxadiazon**
Trade Name:	**RONSTAR 2G**
Chemical Family:	**oxadiazole**
Site of Action:	**Group 14**
Rates of Application	
oxadiazon	2–4.5 kg/ha
RONSTAR 2G (2 Gr)	100–225 kg/ha

Remarks

Use in container nursery stock on: alpine currant, Colorado spruce, dogwood, emerald and gold euonymus, golden elder, juniper, lilac, mugho pine, Nanking cherry, potentilla, Scotch pine, Serbian spruce and vine maple,.

The following plants are sensitive to Ronstar 2G: *Andromeda*, 'Temple Bell' (snowdrift); Calluna 'Mediterranean pink' (heath); *Cotoneaster* 'Eichholz', 'Himalayan', 'Shangri-la'; *Hibiscus* 'Red Heart'; *Picea abies* 'Primila' (Primila Norway spruce); *Picea glauca* 'Densena' (Densena white spruce); *Rhododendron* 'Pink Champagne', 'Everest', 'Girard Roberta', 'John Hearrens', 'Hershey', 'Himo-Crimson', 'Leuchtenfuer', 'Memoire', 'Nova Zimbela' (azalea), 'White Grandeur'; *Tsuga canadensis* 'Pendula' (weeping hemlock); *Viburum davidii*.

Sensitive Weeds

Annual weeds including annual bluegrass, barnyard grass, bittercress, black nightshade, common groundsel, crabgrass, green foxtail, lamb's-quarters, pigweed, purslane, redroot pigweed, shepherd's-purse, stinkweed, tumble, and yellow foxtail.

Uptake and Translocation

Primarily through emerging shoots when they penetrate through the treated soil layer.

Basis of Selectivity

Greater physiological tolerance relative to susceptible species and lack of contact with sensitive crop tissue.

Application Method

Use on newly transplanted and established ornamentals and trees. Apply uniformly to soil. Apply at any time of the year before weed seeds germinate. Remove existing weed growth for satisfactory weed control. Do not apply to wet foliage or when granules can collect on leaves. Apply the herbicide at least 4 weeks before covering polyhouses in the fall.

Residual Activity

60–120 days

Unique Characteristics

Because moisture activates the chemical, rainfall or overhead irrigation after application improves weed control. When the product is applied to soil, it is rapidly and strongly fixed by soil colloids. This adsorption to soil, along with the product's limited water solubility, mean the product is not easily leached.

Manufacturer: Bayer CropScience Inc.

Common Name:	**propyzamide**
Trade Name:	**KERB 50 WSP**
Chemical Family:	**amide**
Site of Action:	**Group 15**
Rates of Application	
propyzamide	1.5 kg/ha
KERB (50WG)	3 kg/ha

Remarks:

Use on coniferous trees and shrubs, established iris, peony and ground covers. Do not use on *Vinca minor.*

Sensitive Weeds

Perennial grasses including quack grass, annual grasses, volunteer cereals and common chickweed.

Uptake and Translocation

Taken up by plant roots and translocated to foliage. Little foliar absorption.

Basis of Selectivity

Faster degradation in tolerant species.

Application Methods

Use as a preemergence treatment for annual weeds, or apply it in the fall for postemergence control of perennial grasses. Apply from late September to November when the soil temperature is low but above freezing and soil moisture is high.

Residual Activity

Persists 2–9 months, depending on soil type and climate. Decomposes slowly at temperatures below 1°C but accelerates at temperatures above this level. Persistence is greatest in sandy soils with low organic matter.

Unique Characteristics

Rainfall or irrigation is required after application. This moves the herbicide into the root zone for uptake by perennial grasses and germinating annual grasses.

Manufacturer: Dow AgroSciences Canada Inc.

Common Name:	**simazine**
Trade Name:	**PRINCEP NINE-T** **SIMADEX**
Chemical Family:	**S-triazine**
Site of Action:	**Group 5**
Rates of Application	
Field applications	
simazine	2.3–3.4 kg/ha
PRINCEP NINE-T (90WG)	2.5–3.8 kg/ha
simazine	1.8–6.8 kg/ha
SIMADEX (500 g/L)	3.6–13.5 kg/ha
Container applications	
simazine	2.3 kg/ha
PRINCEP NINE-T (90WG)	2.5 kg/ha

Remarks

Use on new or established Christmas tree and woodland plantations (2 years or older white pine and balsam fir). Use Princep Nine-T (only) for conifer site preparation before planting fir, pine and spruce.

Use on woody ornamentals and nursery stock established at least 1 year: apple, barberry, black walnut, boxwood, cedar, chamaecyparis, cotoneaster, dogwood, flowering crabapple, hemlock, holly, juniper, mugo pine, multiflora rose, peony, rose, spruce, white ash and yew.

Use on container nursery stock: *Juniperus, Thuja* and *Taxus* only.

Sensitive Weeds

Annual broadleaf weeds such as clover (volunteer), groundsel, plantain, lady's-thumb, lamb's-quarters, pigweed, purslane, ragweed, smartweed and wild buckwheat. Annual grasses such as barnyard grass, crabgrass, wild oats and yellow foxtail. Most perennial species starting freshly from seed. Does not control triazine-resistant biotypes of groundsel, foxtail, lamb's-quarters and pigweed.

Uptake and Translocation

Absorbed by roots, but little or no foliar absorption. Translocated upwards in xylem, accumulating in apical meristem and leaves on new plantings of apples, apricots, cherries, peaches, pears and plums.

Basis of Selectivity

Some species, such as corn, metabolize simazine. In most crops, selectivity depends on crop-plant roots being deeper than the depth to which simazine leaches.

Application Methods

Remove any existing weeds from containers before application. Apply once per season, 1 month after planting and before weeds emerge.

Residual Activity

Persists longer than atrazine. Soil residues may persist for more than 1 season. Do not plant any crop but corn in the treated area for 1 year after a simazine application. If more than 2 kg/ha of product was applied, do not plant rotational crops the following year. If in any doubt, test the soil for excess residues.

Unique Characteristics

Apply only once per season. Needs sufficient moisture to activate. Rotate with non-triazine residual herbicides to avoid resistant weeds. Where rainfall causes erosion, soil containing simazine may wash to lower land and injure existing or subsequent crops.

Manufacturer:

PRINCEP NINE-T: Syngenta Crop Protection Canada Inc.

SIMADEX: Bayer CropScience Inc.

Common Name:	**s-metolachlor**
Trade Name:	**DUAL II MAGNUM**
Chemical Family:	**acetanilide**
Site of Action:	**Group 15**
Rates of Application	
s-metolachlor (915 g/L)	0.14–1.6 kg/ha
DUAL II MAGNUM	1.25–1.75 L/ha

Remarks

Use on second year or older white spruce, Norway spruce, black spruce, white pine, Jack pine and red pine transplant or seedling stock. Also for use on poplar stoolbeds and second year, non-bearing fruit trees. Use on outdoor ornamentals (woody and herbaceous): *Euonymus alata, Hemerocallis, Hosta, Juniperus, Rhododendron, Thuja.* May be used for field-grown conifers that are established: *Abies balsamea, Abies fraseri, Picea glauca, Pinus strobus.*

May be applied as a preemergent or early postemergent application to weeds before they pass the two-leaf stage. For poplar stoolbeds, apply to dormant and flushing stoolbeds.

Apply to soil before bud break. Do not apply Dual II Magnum within 4 weeks after bud burst or until the needles have hardened. Do not use on sandy soils with less than 2% organic matter.

Sensitive Weeds

Annual broadleaf weeds and grasses such as American nightshade, barnyard grass, eastern black nightshade, fall panicum, giant foxtail, green foxtail, hairy crabgrass, redroot pigweed (suppression only), smooth crabgrass, witch grass, yellow foxtail, yellow nut sedge.

Uptake and Translocation

Absorbed by germinating grasses mainly through the shoot, just above the seed. Absorbed by germinating broadleaf weeds through roots and shoots.

Basis of Selectivity

Metabolized by tolerant species.

Application Methods

Early preplant, preplant incorporated or preemergence. Early postemergence on corn (spike to two-leaf stage of corn). Set incorporation equipment to work the soil 10 cm deep with a disc operating at 6–10 km/hr or a vibrating shank cultivator at 10–13 km/hr. One incorporation is sufficient and need not be immediate. Rainfall within 10 days is required for maximum activity of the preemergence application.

Residual Activity

Activity will normally last for 10–14 weeks.

Unique Characteristics

The rate required depends on weed pressure (use a higher rate for heavier weed pressure). Yellow nut sedge control requires a preplant incorporated application. Winter cereals may be planted 4–5 months after s-metolachlor application. Many tank mix combinations are registered for various crops. Do not use on muck soils or coarse-textured soils low in organic matter.

Manufacturer: Syngenta Crop Protection Canada Inc.

Common Name: trifluralin

Trade Name: BONANZA 400 EC, RIVAL EC, TREFLAN EC

Chemical Family: dinitroaniline

Site of Action: Group 3

Rates of Application

trifluralin	0.6–1.15 kg/ha
BONANZA 400 EC (400 g/L)	1.5–2.75 L/ha
RIVAL EC	1.2–2.3 L/ha
TREFLAN EC (480 g/L)	1.1–2.1 kg/ha

Remarks

Use with field-grown nursery stock, perennials (except *Ajuga*, *Vinca* and *Pachysandra*) and established shelterbelts.

Sensitive Weeds

Effective on most annual grasses. Provides good control of pigweed and lamb's-quarters, including the triazine-tolerant biotypes of these weeds.

Uptake and Translocation

No significant absorption or translocation in crops. Controls susceptible weeds as they germinate. Does not control established weeds.

Basis of Selectivity

Physiological growth processes associated with seed germination.

Application Methods

Preplant incorporated. Apply in 100–300 L water/ha. Use a lower rate of the chemical on sandy soils and a greater rate for loam-to-clay soils. Do not use on soils with a high organic content (muck, peat or black sands with more than 15% organic matter). Incorporate twice in cross directions using a tandem disc (7–10 km/hr) or tine cultivator (10–13 km/hr) set 8–10 cm deep. Incorporate immediately after application if possible, although a delay of up to 24 hours is acceptable, as per label directions. Incorporate again any time before planting. Trifluralin is activated upon incorporation. Irrigation is not required.

Residual Activity

Recommended application rates provide season-long weed control. Trifluralin does not injure succeeding crops under normal conditions. Fall-seeded grain crops will grow in soil treated with trifluralin the preceding spring.

Unique Characteristics

Strongly absorbs to soil particles and shows negligible leaching. Organic matter and clay content influence the application rate. Does not control ragweed, annual nightshades or mustards. Lady's thumb may escape.

Manufacturer:

BONANZA: United Agri Products
RIVAL: NuFarm Agriculture Inc.
TREFLAN: Dow AgroSciences Canada

POSTEMERGENCE TREATMENTS

Postemergence treatments are applied after crops and weeds emerge.

- Selective chemicals kill weeds with little damage to desirable plants.
- Many postemergent treatments are non-selective and can damage desirable plants if used carelessly.
- The types of weeds controlled depend on weed susceptibility and crop tolerance to the chemical. Treatments must be applied at the correct stage of crop development. Since weed susceptibility is greatest when most weeds are young, early treatments need less herbicide and cause less crop damage.
- Some herbicides may be applied for preemergence weed action after the crop has emerged. For example, after a crop has been cultivated to ensure the soil is weed-free, a herbicide can be applied to control the weeds that subsequently germinate.

The following chemicals may be used as postemergence treatments.

Common Name:	**amitrole**
Trade Name:	**AMITROL 240**
Chemical Family:	**triazole**
Site of Action:	**Group 11**

Rates of Application

amitrole	0.39–0.69 kg/ha
AMITROL 240	1.7–3.0 L/ha

Remarks

To be applied only on spruce (*Picea* spp.).

Caution: Avoid application during the period of rapid shoot elongation in the spring. Applications can be made in the first year (1.7 L/ha) either in the seedbed or on transplants, but only after the seedlings have set bud. For actively growing seedlings or transplant bareroot spruce beyond the first year of growth, the rate may be increased to 3.0 L/ha. This product has activity against a wide range of plants (both evergreen and deciduous). Avoid spray drift into non-target areas.

Sensitive Weeds

Many annual and perennial broadleaf weeds and grasses, including ash, Canada thistle, cattail, dandelions, hoary cress, honeysuckle, horsetail, leafy spurge, locust, milkweed, poison-ivy, poison-oak, quack grass, sow-thistle, sumac and toadflax.

Uptake and Translocation

Absorbed by foliage and roots. Translocates well in the xylem and phloem. Accumulates in the growing regions of the plant.

Basis of Selectivity

Resistant plants metabolize amitrole more rapidly than sensitive plants and may have lower uptake as a result of leaf structure that reduces wetting and penetration.

Application Methods

Use foliar postemergence application for actively growing plants. Good coverage is essential. If weeds are mature, it is advisable to cut them and then spray the regrowth. Do not disturb treated plants for at least 2 weeks after application. Do not make postharvest applications after October 1. For control

of quack grass and Canada thistle, apply in spring or fall to actively growing plants 15–20 cm tall, then wait 10–14 days to plough or disk. Poor results may occur if heavy rain falls within 6 hours after application.

Residual Activity

Approximately 2–4 weeks in moist, warm soil.

Manufacturer: Nufarm Agriculture Inc.

Common Name: fluazifop-p-butyl

Trade Name: VENTURE L

Chemical Family: aryloxyphenoxypropionate

Site of Action: Group 1

Rates of Application

fluazifop-p-butyl	0.075–0.25 kg/ha
VENTURE L (125 g/L)	0.6–2.00 L/ha

Remarks

Use for field and container application. Good on non-grassy ornamental plants, shrubs, trees, non-bearing forest and ornamental nursery field stock and container-grown nursery stock. Over-the-top application can injure some blue junipers (e.g., *Juniperus horizontalis* 'Bar Harbour', 'Blue Acres' and 'Blue Rug').

Cultivars differ in sensitivity to Venture L. For example, *J. horizontalis* 'Blue Acres' is sensitive, while *J. horizontalis* 'Plumosa Compacta' is tolerant. Consult the label for tolerant species. Test samples of each cultivar not specifically listed on the label before using this product.

Sensitive Weeds

Annual grass species, quack grass and volunteer corn, wheat and barley.

Uptake and Translocation

Absorbed primarily by leaves. Translocated to roots and rhizomes.

Basis of Selectivity

Metabolism by tolerant species.

Application Methods

Postemergence. Use a directed application in sensitive species to avoid contacting leaves and green tissue. Use higher application rates for quack grass. Apply to actively growing grasses when annual grasses are in the 2–5-leaf stage and quack grass is in the 3–5-leaf stage.

Residual Activity

None.

Unique Characteristics

Using preplant tillage to break up rhizomes improves quack grass control. Do not cultivate for 5 days after application. Except as noted on the label, apply broadleaf herbicides separately at least 3 days after using this product. The product loses some effectiveness when used on stressed plants (e.g., when plants are suffering from lack of moisture, excessive humidity, low temperature or very low relative humidity). Weeds may regrow by tillering if the product is applied to stressed plants. A new flush of weeds may emerge after the first flush is controlled.

Manufacturer: Syngenta Crop Protection Canada Inc.

Common Name: **glyphosate**

Trade Name: **various products**

(see OMAFRA Publication 75, Guide to Weed Control, or contact a local supplier)

Chemical Family: **amino acid**

Site of Action: **Group 9**

Rates of Application

Emerged annual weeds

glyphosate 0.8–1.25 kg/ha

Emerged perennial weeds

glyphosate 1.7–4.3 kg/ha

Quack grass & other perennial grasses

glyphosate 0.9–2.5 kg/ha

Perennial weeds (bindweed, Canada thistle, dogbane, milkweed, sow thistle)

glyphosate 2.5–4.3 kg/ha

(See product label)

Remarks

Apply to actively growing weeds. Spray must not contact leaves or green bark of trees or shrubs.

Crop and/or Non-Crop Registrations

See OMAFRA Publication 75, *Guide to Weed Control.*

Sensitive Weeds

Annual grasses, perennial weeds (e.g., Canada thistle, cattails, field bindweed, milkweed, nut sedge, poison–ivy, quack grass, sow thistle) and brush (e.g., alder, birch, maple, poplar, raspberry and willow).

Uptake and Translocation

Absorbed through foliage and translocated throughout the plant.

Basis of Selectivity

Non-selective for agricultural crops. Conifers are tolerant at some stages for unknown reasons.

Application Methods

Use postemergence for perennial weed control. Apply at the bud-bloom growth stage to most perennial weeds. For Canada thistle or sow thistle, wait until they are at least in early flower bud. Apply to milkweed at flower bud. Apply to bindweed at full flower. Treat quack grass in the spring or fall while it is actively growing, with at least three or four new leaves on each emerged shoot.

Remove crop refuse in the fall, but do not till before application. Fall or spring tillage before spring application may reduce weed control. Wait at least 3–5 days after application before working the area. For maximum quack grass control, till before the quack grass turns completely brown.

Glyphosate can be applied with boom equipment, knapsack sprayers and high-volume spray equipment for agricultural and non-crop uses. Use backpack mist blowers only for silvicultural site preparation and roadside brush control. Use aerial applications only for silvicultural site preparation and conifer release.

Glyphosate may be applied with selective equipment to non-crop areas, tree plantings, grapes and orchards. (See *Wiper Applicators for Selective Weed Control*, on page 168.) Regardless of the application method, do not allow the herbicide to contact green foliage or the green bark of crops or other desirable plants. Remove all suckers from the trunks of desirable trees before spraying.

Residual Activity

None. Crops can be planted or seeded directly into treated areas following application. Use other herbicides to control weeds emerging after the application.

Unique Characteristics

Rainfall within 6 hours after application can reduce control, as can a heavy frost.

Manufacturers: ***Cheminova Canada***
Dow Agrosciences Canada Inc.
Interprovincial Cooperative Ltd.
Monsanto Canada Inc.
NuFarm Agriculture Inc.
Syngenta Crop Protection Canada Inc.

Common Name:	**paraquat**
Trade Name:	**GRAMOXONE**
Chemical Family:	**bipyridylium**
Site of Action:	**Group 22**

Rates of Application

paraquat	0.55–1.1 kg/ha
GRAMOXONE (200 g/L)	2.75–5.5 L/ha

Remarks

Use for emerged annual weeds and to suppress top growth in perennial weeds.

Crop and/or Non-Crop Registrations

- stale seedbed technique
- inter-row directed chemical weeding for established nursery crops
- chemical mowing weed control in non-crop land

Sensitive Weeds

Non-selective action affects all green plants.

Uptake and Translocation

Absorbed by foliage and green bark. Little or no translocation.

Basis of Selectivity

All green plant tissue is sensitive. Paraquat is less effective on plants with a very waxy cuticle and linear leaf shape (e.g., nut sedge). It is safe on the mature (non-green) bark of woody plants.

Application Methods

Postemergence. Apply when weeds are under 15 cm high. Use as a chemical mower, applying it several times a year to actively growing vegetation. Aim the spray to avoid the leaves and green bark of nursery plants. For spot treatment, use 25 mL in 4 L of water. Paraquat only controls emerged weeds. It suppresses perennial weeds. Paraquat can be broadcast if there is no danger to the leaves or bark of desirable plants. For best results, apply it on a dull or cloudy day or in the evening.

Residual Activity

Essentially no residual soil activity. Persists in organic material (e.g., mulches, turf thatch). Do not reseed such areas for 5 days. Perennial weeds may need multiple applications per season.

Unique Characteristics

Inactivated by adsorption to soil particles.

Manufacturer: Syngenta Crop Protection Canada Inc.

Crop Tolerance and Efficacy of Herbicides Registered on Nursery Crops

The following pages contain charts listing information about herbicides registered in Ontario for use on nursery stock (agricultural use). The following tables outline the tolerance of specific nursery crops and also provide weed control ratings for herbicides registered on nursery stock.

In April 2009, the Ministry of Environment amended the *Pesticides Act* with the *Cosmetic Pesticides Ban Act*, 2008 and Ontario Regulation 63/09. Pesticides are now classified for sale and use under 11 different classes. Note that agriculture (including nursery production) is excepted. For more information on the legislation, see the Ministry of the Environment's website at www.ontario.ca/pesticideban.

TABLE 6–3. Herbicides Registered for Use on Woody Plants

Botanical Name	English Name	Preemergent						
		CASORON	DUAL II MAGNUM	DEVRINOL	VENTURE L	KERB	RONSTAR	SIMADEX, PRINCEP NINE-T
Abies balsamea	balsam fir	Not				F		F
Abies sp.	fir	Not			TFC	F		
Acer circinatum	vine maple						C[2]	
Acer sp.	maple	T[1]F		TFC	TFC			
Ajuga sp.	bugleweed	Not						
Betula pendula 'Gracilis'	cutleaf weeping birch	T[1]F						
Buxus sp.	boxwood	T[1]F		TFC	TFC			F
Calluna sp.	heather	T[1]F			TFC			
Caragana sp.	peashrub	T[1]F			TFC			F
Carpinus sp.	blue beech				TFC			
Chaenomeles sp.	flowering quince				TFC			
Chamaecyparis sp.	false cypress							F
Cornus sp.	dogwood				TFCD		C[2]	F
Cotinus coggygria	smoke bush				TFC			
Cotoneaster sp.	cotoneaster				TFC			F
Crataegus sp.	hawthorn			TFC				
Euonymus fortunei 'Emerald & Gold'	Emerald & Gold euonymus						C[2]	
Erica sp.	heath	T[1]F						
Euonymus sp.	euonymus	T[1]F		TFC	TFC			
Forsythia sp.	forsythia	T[1]F			TFC			
Fraxinus americana	white ash							F
Fraxinus sp.	ash	T[1]F			TFC			
Gleditsia sp.	honeylocust			TF	TFC			
Gleditsia triacanthos	honeylocust				T			
Hedera sp.	English ivy			C	TFC			
Hibiscus sp.	rose of Sharon			TF				
Hydrangea sp.	hydrangea				TFC			
Hypericum sp.	hypericum			TF				
Ilex sp.	holly	T[1]F		TFC	TFC[3]			F
Juglans nigra	black walnut							F
Juniperus chinensis Pfitzeriana	Pfitzer juniper	T[1]FC[1,2]			TFCD	F		
Juniperus sabina	sabina juniper	T[1]FC[1,2]				F		
Juniperus scopulorum	Rocky Mountain juniper	T[1]				F		
Juniperus sp.	juniper	T[1]F		TFC	TFC[3]	F	C[2]	FC
Juniperus virginiana	eastern red cedar	T[1]F				F		
Laburnum sp.	golden chain tree			TF				
Ligustrum sp.	privet			TFC	TFC			
Lonicera sp.	honeysuckle	T[1]F			TFC			
Malus sp.	flowering crabapple	T[1]F		TF	TFC			F

Botanical Name	English Name	Preemergent						
		CASORON	DUAL II MAGNUM	DEVRINOL	VENTURE L	KERB	RONSTAR	SIMADEX, PRINCEP NINE-T
Malus sylvestris	apple (non-fruiting)			TFC			F	
Parthenocissus quinquefolia	Virginia creeper				TFC			
Philadelphus sp.	mock orange	T F			TFCD			
Picea abies	Norway spruce	Not				F		F
Picea abies 'Nidiformis'	nest spruce	Not				F		
Picea glauca	white spruce	Not				F		F
Picea glauca 'Conica'	dwarf Alberta spruce	Not				F		
Picea marina	black spruce		TF					
Picea omorika	Serbian spruce	Not					C[2]	
Picea pungens	Colorado spruce	Not					C[2]	
Picea pungens 'Glauca'	blue Colorado spruce	Not				F		F
Picea pungens 'Glauca Globosa'	globe blue spruce	Not				F		F
Picea rubens	red spruce	Not				F		F
Picea sp.	spruce	Not		TF	TFC[1]	F		
Pieris sp.	Japanese pieris				TFC			
Pinus banksiana	jackpine		TF					
Pinus mugo	mugo pine	Not				F	C[2]	F
Pinus nigra	Austrian pine					F		
Pinus resinosa	red pine		TF					
Pinus sp.	pine			TFC	TFC	F		
Pinus strobus	white pine 2 year		TF		F		F	
Pinus sylvestris	Scots pine						C[2]	
Pittosporum sp.	pittosporum			TF				
Platanus sp.	planetree				TFC			
Podocarpus sp.	podocarpus			TFC				
Populus sp.	poplar		stoolbed	TF				
Potentilla sp.	cinquefoil				TFC		C[2]	
Prunus sp.	cherry (non-producing)			TF				
Prunus tomentosa	Nanking cherry						C[2]	
Pseudotsuga menzeisii	Douglas fir				TFC[1]	F		
Pyracantha sp.	firethorn			TFC	TFC			
Pyrus sp.	pear (non-producing)							
Rhododendron sp.	rhododendron, azalea	T F		TFC	TFC			
Ribes alpinum	alpine currant						C[2]	
Ribes sp.	currant (non-producing)				TFC			

TABLE 6–3. Herbicides Registered for use on Woody Plants *continued*

Botanical Name	English Name	Preemergent						
		CASORON	DUAL II MAGNUM	DEVRINOL	VENTURE L	KERB	RONSTAR	SIMADEX, PRINCEP NINE-T
Rosa multiflora	multiflora rose							F
Rosa sp.	rose	T[1]F		TFC	TFC			F
Salix sp.	willow	T[1]F			TFC			
Sambucus canadensis 'Aurea'	golden elderberry						C[2]	
Sambucus sp.	elderberry				TFC			
Spiraea sp.	spirea	T[1]F			TFC			
Symphoricarpos rivularis	snowberry				TFC			
Syringa sp.	lilac	Not			TFC		C[2]	
Taxus cuspidata	Japanese yew					F		
Taxus sp.	yew	T[1]FC[1,2]		TF	TFC[3]	F		FC
Thuja occidentalis	white cedar	T[1]FC[1,2]				F		
Thuja sp.	cedar	T[1]F		C	TFC	F		FC
Tilia sp.	linden, basswood	T[1]F			TFC			
Tsuga sp.	hemlock	Not			TFC[3]			F
Ulmus sp.	elm	T[1]F			TFC			
Viburnum sp.	viburnum				TFC			
Weigela sp.	weigela				TFC			

[1] Apply 4 weeks after transplanting.

[2] Apply 30 days before covering polyhouses; no later than Sept. 30.

[3] Use directed spray from bud break to initial growth hardening.

C = Container
D = Directed spray only
F = Field
Not = Labelled restriction
S = Seedbed
T = Transplant

TABLE 6–4 Weed Susceptibility and Herbicides — Broadleaf Annuals

Broadleaf Annuals	CASORON	DUAL II MAGNUM	DEVRINOL	KERB	RONSTAR	SIMADEX, PRINCEP NINE-T	TREFLAN, RIVAL
bittercress	S				S		
buckwheat, wild	S					S	MS
carpetweed			S				S
chickweed, common	S		S	S			S
clover, volunteer						S	
groundsel, common	S		S		S		
knotweed	S						
knotweed, prostrate			S				S
kochia	S						
lady's thumb						S	
lamb's-quarters	S		S		S	S	S
mustards	S						

Broadleaf Annuals	CASORON	DUAL II MAGNUM	DEVRINOL	KERB	RONSTAR	SIMADEX, PRINCEP NINE-T	TREFLAN, RIVAL
nightshade, black		MS			S		
pigweed	S		S		S		S
pigweed, redroot			S			S	
pineappleweed			S				
plantain	S						
prickly lettuce			S				
purslane	S		S		S	S	S
ragweed, common			MS			S	
Russian thistle							S
shepherd's-purse	S				S		
smartweed	S					S	S
smartweed, green						S	
sow thistle, annual	S		S				
spurge	S						
stinkweed					S		

S = Susceptible; MS = Moderately Susceptible; T = Tolerant

TABLE 6–5. Weed Susceptibility and Herbicides — Broadleaf Perennials

Broadleaf Perennials	CASORON	DUAL II MAGNUM	DEVRINOL	VENTURE L	KERB	RONSTAR	SIMADEX	TREFLAN	ROUNDUP
bindweed	T							T	S
chickweed, mouse eared	MS							MS	S
dandelion	MS		T						MS
grape, wild	T								MS
ground ivy (creeping Charlie)	MS								MS
horsetail	MS						T	T	MS
mallow									MS
milkweed								T	S
nut sedge	MS	S	MS	T			T	T	MS
plantain	MS								S
poison-ivy				S					
quack grass	MS		T	MS	MS		T	T	
sow thistle	MS				S		T	T	
stinging nettle				S					
thistle, Canada	MS						T	T	
toadflax, yellow				S	S				S
vetches	MS		T				T	T	

S = Susceptible; MS = Moderately Susceptible; T = Tolerant

TABLE 6–6. Weed Susceptibility and Herbicides — Annual Grasses

Annual Grasses	CASORON	DUAL II MAGNUM	DEVRINOL	VENTURE L	KERB	RONSTAR	SIMADEX	TREFLAN	ROUNDUP
barnyard grass		S	S	S		S	S	S	
bluegrass, annual	S		S			S		S	S
brome grass								S	S
cheat grass								S	
crabgrass	S		S	S		S	S	S	
crabgrass, large			S						S
crabgrass, smooth		S							
darnel, Persian				S				S	
foxtail, giant		S		S					
foxtail, green	S	S	S	S		S		S	S
foxtail, yellow	S	S	S	S		S	S	S	
goosegrass			S					S	
grasses, annual					S				
Johnson grass				S					
love (stink) grass								S	
oats, wild			S	S	S		S	S	S
panicum, fall		S	S					S	
proso millet				S					
ryegrass			S						
witch grass		S							

S = Susceptible; M = Moderately Susceptible; T = Tolerant

7. Appendices

Appendix A. Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Nursery Crop Advisory Staff

Jen Llewellyn

OMAFRA Nursery Crops Specialist
Bovey Building
University of Guelph
Guelph, ON N1G 2W1
Tel: 519-824-4120, ext. 52671
Fax: 519-767-0755
E-mail: jennifer.llewellyn@ontario.ca

A complete list of Ontario Ministry of Agriculture, Food and Rural Affairs advisory staff is available on the ministry website at www.ontario.ca/crops.

Agricultural Information Contact Centre
Provides province-wide, toll-free technical and business information to commercial farms, agri-businesses and rural businesses.
1 Stone Road West
Guelph ON N1G 4Y2
1-877-424-1300 or 519-826-4047
Fax: 519-826-7610
E-mail: ag.info.omafra@ontario.ca

Appendix B. Ontario Ministry of the Environment Regional Contact Information

Central Region Toronto, Halton, Peel, York, Durham	5775 Yonge Sreet, 8th Floor Toronto, ON M2M 4J1	Tel: 416-326-6700 Toll-free: 1-800-810-8048 Fax: 416-325-2459
West-Central Region Haldimand-Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant	Ontario Government Building 119 King Street West, 12th Floor Hamilton, ON L8P 4Y7	Tel: 905-521-7640 Toll-free: 1-800-668-4557 Fax: 905-521-7820
Eastern Region Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry, Haliburton, Peterborough, Victoria, Northumberland, Renfrew, Ottawa-Carleton, Lanark, South Algonquin (Townships of Airy, Murchison, Dickens, Lyell and Sabine)	1259 Gardiners Road, Unit 3 PO Box 22032 Kingston, ON K7M 8S5	Tel: 613-549-4000 Toll-free: 1-800-267-0974 Fax: 613-548-6908
Southwestern Region Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth, Simcoe	733 Exeter Road, 2nd Floor London, ON N6E 1L3	Tel: 519-873-5000 Toll-free: 1-800-265-7672 Fax: 519-873-5020

Northern Region	Thunder Bay Regional and District Office 435 James Street South, Suite 331 Thunder Bay, ON P7E 6S7	Tel: 807-475-1205 Toll-free: 1-800-875-7772 Fax: 807-475-1754
	Sudbury District Office 199 Larch Street, Suite 1201 Sudbury, ON P3E 5P9	Tel: 705-564-3237 Toll-free: 1-800-890-8516 Fax: 705-564-4180
	Timmins District Office Ontario Government Complex Highway 101 East PO Bag 3080 South Porcupine, ON P0N 1H0	Tel: 705-235-1500 Toll-free: 1-800-380-6615 Fax: 705-235-1520
Standards Development Branch	Pesticides Section 40 St. Clair Avenue West, 7th Floor Toronto, ON M4V 1M2	Tel: 416-327-5519 Fax: 416-327-2936
Approvals Branch	Pesticides Licensing 2 St. Clair Avenue West, 12A Floor Toronto, ON M4V 1L5	Tel: 416-314-8001 Toll-free: 1-800-461-6290 Fax: 416-314-8452

Appendix C. Other Contacts

Agriculture & Agri-food Canada Research Centres

www.agr.gc.ca/index_e.php

Eastern Cereals and Oilseeds Research Centre

960 Carling Avenue
Ottawa, ON K1A 0C6
Tel: 613-759-1858

Greenhouse and Processing Crops Centre

2585 County Road 20
Harrow, ON N0R 1G0
Tel: 519-738-2251

Southern Crop Protection and Food Research Centre

1391 Sandford Street
London, ON N5V 4T3
Tel: 519-457-1470

Delhi Research Farm

Box 186 Schafer Road
Delhi, ON N4B 2W9
Tel: 519-582-1950

Vineland Research Farm

4902 Victoria Ave. N.
Vineland, ON L0R 2E0
Tel: 905-562-4113

Canadian Food Inspection Agency Regional Offices (Plant Protection)

www.inspection.gc.ca/english/toce.shtml

Belleville

345 College Street East
Belleville, ON K8N 5S7
Tel: 613-969-3333

Brantford

625 Park Road North, Suite 6
Brantford, ON N3T 5P9
Tel: 519-753-3478

Hamilton

709 Main Street West, Suite 101
Hamilton, ON L8S 1A2
Tel: 905-572-2201

London

19-1200 Commissioners Road East
London, ON N5Z 4R3
Tel: 519-691-1300

Niagara Falls

350 Ontario Street, Unit 13
P.O. Box 9
St. Catharines, ON L2R 5L8
Tel: 905-357-5981

Ottawa District

38 Auriga Drive, Unit 8
Ottawa, ON K2E 8A5
Tel: 613-274-7374, ext 221

Toronto

1124 Finch Avenue West, Unit 2
Downsview, ON M3J 2E2
Tel: 416-665-5055

University Of Guelph

Main Campus

Guelph, ON N1G 2W1
Tel: 519-824-4120
www.uoguelph.ca

Alfred Campus

Alfred, ON K0B 1A0
Tel: 613-679-2218
Fax: 613-679-2423
www.alfredc.uoguelph.ca

Kemptville Campus

Kemptville, ON K0G 1J0
Tel: 613-258-8336
Fax: 613-258-8384
www.kemptvillec.uoguelph.ca

Ridgetown Campus

Ridgetown, ON N0P 2C0
Tel: 519-674-1500
www.ridgetownc.on.ca

Department of Plant Agriculture

www.plant.uoguelph.ca

Department of Plant Agriculture, Guelph

50 Stone Road East
Guelph, ON N1G 2W1
Tel: 519-824-4120, ext. 56083 or 52693
Fax: 519-763-8933

Department of Plant Agriculture, Simcoe

1283 Blueline Road, Box 587
Simcoe, ON N3Y 4N5
Tel: 519-426-7127
Fax: 519-426-1225

Department of Plant Agriculture, Vineland

Box 7000, 4890 Victoria Avenue North
Vineland Station, ON L0R 2E0
Tel: 905-562-4141
Fax: 905-562-3413

Lab Services Division

95 Stone Road West
Guelph, ON N1H 8J7
www.uoguelph.ca/labserv/

Trace Organic and Pesticide Contaminants
Tel: 519-823-1268

Pest Diagnostic Clinic
Tel: 519-767-6256

Vineland Research And Innovation Centre

4890 Victoria Avenue North
Lincoln, ON L0R 2E0
Tel: 905-562-0320
Fax: 905-562-0084
www.vinelandontario.ca

APPENDIX D. Diagnostic Service

Samples for disease diagnosis, insect or weed identification, nematode counts and *Verticillium* testing can be sent to:

Pest Diagnostic Clinic
Laboratory Services Division
University of Guelph
95 Stone Road West
Guelph, ON N1H 8J7
Tel: 519-767-6256
Fax: 519-767-6240
E-mail: pdc@lsd.uoguelph.ca

Payment must accompany samples at the time of submission. Submission forms are available at www.labservices.uoguelph.ca/units/pdc/.

Fee Schedule

To obtain information on the fee schedule, refer to www.labservices.uoguelph.ca/units/pdc/ or phone the Pest Diagnostic Clinic.

How to Sample for Nematodes

Soil

When to sample

Soil and root samples can be taken at any time of the year that the soil is not frozen. In Ontario, nematode soil population levels are generally at their highest in May and June and again in September and October.

How to sample soil

Use a soil sampling tube, trowel or narrow-bladed shovel to take samples. Sample the soil to a depth of 20–25 cm. If the soil is bare, remove the top 2 cm prior to sampling. A sample should consist of 10 or more subsamples combined. Mix these thoroughly in a clean pail or plastic bag. Then take a sample of 0.5–1 L from this. No one sample should represent more than 2.5 ha.

Sampling pattern

If living crop plants are present in the sample area, take samples within the row and from the area of the feeder root zone (with trees, this is the drip line).

Number of subsamples

Base the number of subsamples on the total area sampled:

For < 500 m^2 (5,400 ft^2), take 10 subsamples

For 500 m^2–0.5 ha (5,400 ft^2–1.25 ac), take 25 subsamples

For 0.5–2.5 ha (1.25–6.25 ac), take 50 subsamples

Roots

For small plants, sample the entire root system plus adhering soil. For large plants, dig 10–20 g (1/2–1 oz.) of fresh weight from the feeder root zone and submit.

Problem areas

Take soil and root samples from the margins of the problem area where the plants are still living. If possible, also take soil and root samples from healthy areas in the same field.

Sample handling

Soil samples

Place in plastic bags as soon as possible after collecting.

Root samples

Place in plastic bags and cover with moist soil from the sample area.

Storage

Store samples at 5°C–10°C (40°C–50°F) and do not expose them to direct sunlight or extreme heat or cold (freezing). Only living nematodes can be counted. Accurate counts depend on proper handling of samples.

Submitting Plant Specimens for Disease Diagnosis or Identification

Sample submission forms

Forms can be obtained from your local Ontario Ministry of Agriculture, Food and Rural Affairs office. Carefully fill in all of the categories on the form. In the space provided, draw the most obvious symptom and the pattern of the disease in the field. It is important to include the cropping history of the area for the past 3 years and this year's pesticide use records.

Choose a complete, representative sample showing early symptoms. Submit as much of the plant as is practical, including the root system, or several plants showing a range of symptoms. If the symptoms affect the whole plant, collect the sample from an area where they are of intermediate severity. Completely dead material is usually inadequate for diagnosis.

With plant specimens submitted for identification, include at least a 20–25-cm sample of the top portion of the stem with lateral buds, leaves, flowers or fruits in identifiable condition. Wrap the plants in newspaper and put them in a plastic bag. Tie the root system off in a separate plastic bag to prevent it from drying out and to prevent the soil from contaminating the plant leaves. Do not add moisture, as this encourages decay in transit. Cushion the specimens and pack them in a sturdy box to prevent damage during shipping. Do not leave specimens to bake or freeze in a vehicle or in a location where they could deteriorate.

Delivery

Deliver to the Pest Diagnostic Clinic as soon as possible by first class mail or by courier at the beginning of the week.

Submitting Insect Specimens for Identification

Collecting samples

Place dead, hard-bodied insects in vials or boxes and cushion with tissues or cotton. Place soft-bodied insects and caterpillars in vials containing alcohol. Do not use water, as this results in rot. Do not tape insects to paper or send them loose in an envelope.

Place live insects in a container with enough plant "food" to support them during transit. Be sure to write "live" on the outside of the container.

UNIVERSITY of GUELPH LABORATORY SERVICES

95 Stone Road West
Guelph, ON N1H 8J7
Tel: (519) 767-6256
Fax: (519) 767-6240
Web: www.uoguelph.ca/pdc

SAMPLE SUBMISSION FORM

Pest Diagnostic Clinic

LABORATORY USE ONLY: LS Form: SubP01/04/03 Pg. 1 of 1

Rec'd: By: _____ **Date Received:** _____

Delivered By: ☐ **Mail** ☐ **Courier** ☐ **In-Person**

LS Sample No: _____ **to** _____

Payment Rec'd: $ _____ __ **Receipt #:** _____

Submitted By:			Owner (if different from submitter):		
Business Name (if applicable):			Business Name (if applicable):		
Street:			Street:		
City:	Prov:	Postal Code:	City:	Prov:	Postal Code:
Tel: ( ) -	Fax: ( ) -		Tel: ( ) -	Fax: ( ) -	
Email:			Email:		

Unless otherwise indicated, report and invoice will be sent to submitter

Report to: ☐ Submitter ☐ Owner Required Report Format: ☐ Fax ☐ E-Mail ☐ Mail

Invoice to: ☐ Submitter ☐ Owner Quotation #: _____ Purchase Order / U of G G/L code: _____

Services Required: ☐ Nematode Count ☐ Nematode Count from Roots ☐ SCN Cyst & Egg Count
☐ Plant Disease Diagnosis ☐ Insect Identification ☐ Plant Identification ☐ Verticillium Count

Plant or Host Affected:	Cultivar/Variety:	Grower/Field sample #:
	Location of Plant (i.e. greenhouse, field, orchard, garden, etc.):	

Size of Planting:	% of Plants Affected:	Symptoms First Appeared in Past: ☐ Days ☐ Weeks ☐ Months ☐ Years	Degree of Injury: ☐ Severe ☐ Moderate ☐ Light
Cropping History:		Future Crop:	

Describe the problem in detail (i.e. symptoms, plant parts affected, distribution of symptoms):

Were chemicals applied? Please specify type of product(s) used and date(s) of application:

Additional comments and specific requests:

Additional Sheet(s) Attached: ☐

Appendix E. The Metric System

Metric Units

Linear measures (length)		
10 millimetres (mm)	=	1 centimetre (cm)
100 centimetres (cm)	=	1 metre (m)
1,000 metres	=	1 kilometre (km)
Square measures (area)		
100 m x 100 m = 10,000 m^2	=	1 hectare (ha)
100 ha	=	1 square kilometre (km^2)
Cubic measures (volume)		
Dry measures		
1,000 cubic millimetres (mm^3)	=	1 cubic centimetre (cm^3)
1,000,000 cm^3	=	1 cubic metre (m^3)
Liquid measures		
1 000 millilitres (mL)	=	1 litre (L)
100 L	=	1 hectolitre (hL)
Weight-volume equivalents (for water)		
(1.00 kg) 1,000 grams	=	1 litre (1.00 L)
(0.50 kg) 500 g	=	500 mL (0.50 L)
(0.10 kg) 100 g	=	100 mL (0.10 L)
(0.01 kg) 10 g	=	10 mL (0.01 L)
(0.001 kg) 1 g	=	1 mL (0.001 L)
Weight measures		
1,000 milligrams (mg)	=	1 gram (g)
1,000 g	=	1 kilogram (kg)
1,000 kg	=	1 tonne (t)
1 mg/kg	=	1 part per million (ppm)
Dry–liquid equivalents		
1 cm^3	=	1 mL
1 m^3	=	1,000 L

Application Rate Conversions

Metric to imperial (approximate)		
litres per hectare x 0.4	=	litres per acre
litres per hectare x 0.11	=	US gallons per acre
litres per hectare x 0.09	=	imperial gallons
litres per hectare x 0.36	=	quarts per acre
litres per hectare x 0.71	=	pints per acre
millilitres per hectare x 0.015	=	fluid ounces per acre
grams per hectare x 0.015	=	ounces per acre
kilograms per hectare x 0.89	=	pounds per acre
tonnes per hectare x 0.45	=	tons per acre
Imperial to metric (approximate)		
litres per acre x 2.5	=	litres per hectare
US gallons per acre x 9.1	=	litres per hectare (L/ha)
imperial gallons per acre x 11.23	=	litres per hectare (L/ha)
quarts per acre x 2.8	=	litres per hectare (L/ha)
pints per acre x 1.4	=	litres per hectare (L/ha)
fluid ounces per acre x 70	=	millilitres per hectare (mL/ha)
tons per acre x 2.24	=	tonnes per hectare (t/ha)
pounds per acre x 1.12	=	kilograms per hectare (kg/ha)
ounces per acre x 70	=	grams per hectare (g/ha)

Liquid equivalents

Litres/hectare		*Approximate gallons/acre*
50	=	5
100	=	10
150	=	15
200	=	20
250	=	25
300	=	30

Dry weight equivalents		
Grams/hectare		*Ounces/acre*
100 grams	=	1½ ounces
200 grams	=	3 ounces
300 grams	=	4¼ ounces
500 grams	=	7 ounces
700 grams	=	10 ounces
Kilograms/hectare		*Pounds/Acre*
1.10 kilograms	=	1 pound
1.50 kilograms	=	1¼ pounds
2.00 kilograms	=	1¾ pounds
2.50 kilograms	=	2¼ pounds
3.25 kilograms	=	3 pounds
4.00 kilograms	=	3½ pounds
5.00 kilograms	=	4½ pounds
6.00 kilograms	=	5¼ pounds
7.50 kilograms	=	6¾ pounds
9.00 kilograms	=	8 pounds
11.00 kilograms	=	10 pounds
13.00 kilograms	=	11½ pounds
15.0 kilograms	=	13½ pounds
Small volume conversions		
5 mL	=	1 tsp
15 mL	=	1 tbsp
28.5 mL	=	1 fl. oz

Conversion Tables — Metric to Imperial

Length		
1 millimetre (mm)	=	0.04 inches
1 centimetre (cm)	=	0.40 inches
1 metre (m)	=	39.40 inches
1 metre (m)	=	3.28 feet
1 metre (m)	=	1.09 yards
1 kilometre (km)	=	0.62 mile
Area		
1 square centimetre (cm^2)	=	0.16 square inches
1 square metre (m^2)	=	10.77 square feet
1 square metre (m^2)	=	1.20 square yards
1 square kilometre (km^2)	=	0.39 square miles
1 hectare (ha)	=	107,636 square feet
1 hectare (ha)	=	2.5 acres
Volume (dry)		
1 cubic centimetre (cm^3)	=	0.061 cubic inches
1 cubic metre (m^3)	=	1.31 cubic yards
1 cubic metre (m^3)	=	35.31 cubic feet
1,000 cubic metres (m^3)	=	0.81 acre-foot
1 hectolitre (hL)	=	2.8 bushels
Volume (liquid)		
1 millilitre (mL)	=	0.035 fluid ounces
1 litre (L)	=	1.76 pints
1 litre (L)	=	0.88 quarts
1 litre (L)	=	0.22 gallon (Imp.)
1 litre (L)	=	0.26 gallon (U.S.)
Weight		
1 gram (g)	=	0.035 ounces
1 kilogram (kg)	=	2.21 pounds
1 tonne (t)	=	1.10 short tons
1 tonne (t)	=	2,205 pounds
Pressure		
1 kilopascal (kPa)	=	0.15 pounds per square inch
Speed		
1 metre per second	=	3.28 feet per second
1 metre per second	=	2.24 miles per hour
1 kilometre per hour	=	0.62 miles per hour
Temperature		
°F	=	(°C x 9/5) + 32

Conversion Tables — Imperial to Metric

Length		
1 inch	=	2.54 cm
1 foot	=	0.30 m
1 yard	=	0.91 m
1 mile	=	1.61 km
Area		
1 square foot	=	0.09 m^2
1 square yard	=	0.84 m^2
1 acre	=	0.40 ha
Volume (dry)		
1 cubic yard	=	0.76 m^3
1 bushel	=	36.37 L
Volume (liquid)		
1 fluid ounce (Imp.)	=	28.41 mL
1 pint (Imp.)	=	0.57 L
1 gallon (Imp.)	=	4.55 L
1 gallon (U.S.)	=	3.79 L
Weight		
1 ounce	=	28.35 g
1 pound	=	453.6 g
1 ton	=	0.91 t
Pressure		
1 pound per square inch	=	6.90 kPa
Temperature		
°C	=	(°F – 32) x 5/9

Abbreviations

%	= per cent (by weight)	km/h	= kilometres per hour
ai	= active ingredient	kPa	= kilopascal
AP	= agricultural powder	L	= litre
cm	= centimetre	m	= metre
cm^2	= square centimetre	m/s	= metres per second
DG	= dispersible granular	m^2	= square metre
DP	= dispersible powder	mL	= millilitre
E	= emulsifiable	mm	= millimetre
EC	= emulsifiable concentrate	SC	= sprayable concentrate
e.g.	= for example	SP	= soluble powder
F	= flowable	t	= tonne
g	= gram	W	= wettable (powder)
Gr	= granules, granular	WDG	= water dispersible granular
ha	= hectare	WP	= wettable powder
kg	= kilogram		

Appendix F. Pest Monitoring Record Sheet

Date *(MM/DD/YY)*	**Location** *(farm, block, landmarks)*	**Host** *(include variety/cultivar, development stage)*	**Pest and/or Symptoms** *(development stage, population, % of crop showing symptoms)*	**GDD, Plant Phenology Indicator**	**Action Taken** *(pesticides, cultural measures, etc.)*

Appendix G. Colour Plates

PLATE 1. Early instar spruce budworm *(Choristoneura fumiferana)* larva in May.

PLATE 2. Adult female cottony maple scale *(Pulvinaria innumerabilis)* with cottony mass of eggs. (Photo: Dave Cheung, University of Guelph)

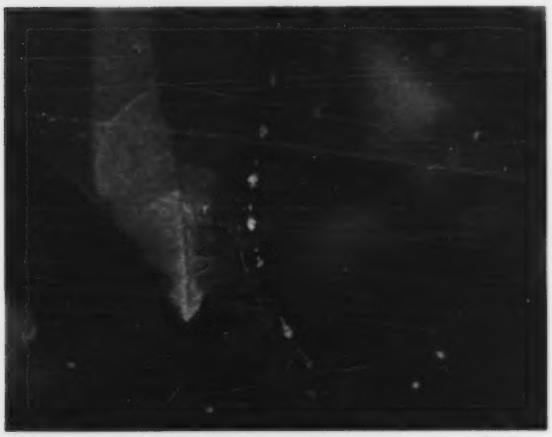

PLATE 3. Late instar larvae of the forest tent caterpillar *(Malacosoma disstria)*.
(Photo: Dave Cheung, University of Guelph)

PLATE 4. Adult female European fruit lecanium scale *(Lecanium corni)*.

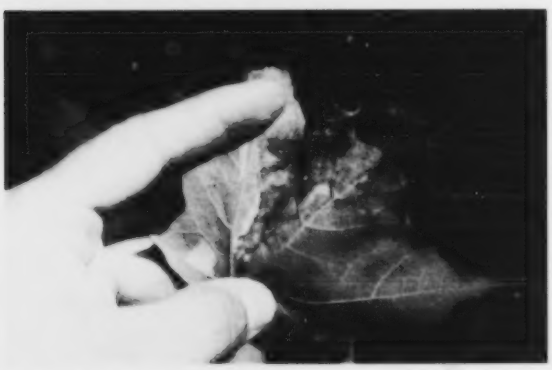

PLATE 5. Leaf webbing and feeding damage caused by the maple trumpet skeletonizer *(Epinotia aceriella)*.

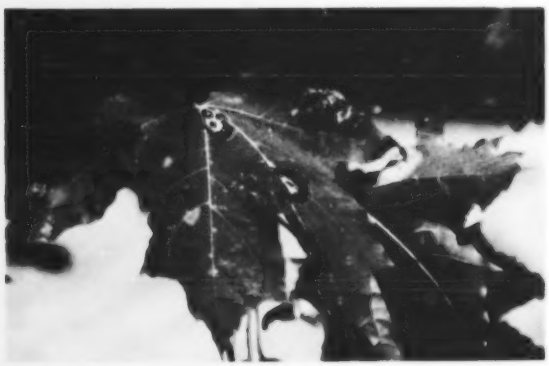

PLATE 6. Tar spot *(Rhytisma acerinum)* lesions on *Acer platanoides*, early August.

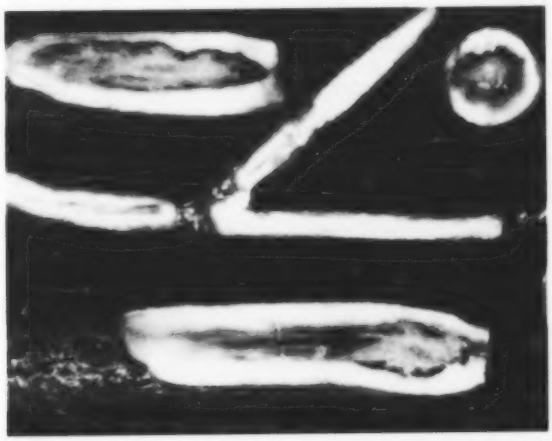

PLATE 7. Verticillium *(V. dahliae, V. albo-atrum)* wilt staining on heartwood (xylem) of *Acer* sp.

PLATE 8. Leaf blotch *(Guignardia aesculi)* on *Aesculus* sp., July.

PLATE 9. Mines on birch leaves caused by the birch leaf miner *(Fenusa pusilla* and other spp.*)*, late May. (Photo: Dave Cheung, University of Guelph)

PLATE 10. Larval tunnels of bronze birch borer *(Agrilus anxius)*. The tunnels circle the trunk, causing raised swellings in bark similar to varicose veins.

PLATE 11. D-shaped exit hole (approx 2 mm) in bark caused by bronze birch borer *(Agrilus anxius)* adult. (Photo: Dave Cheung, University of Guelph)

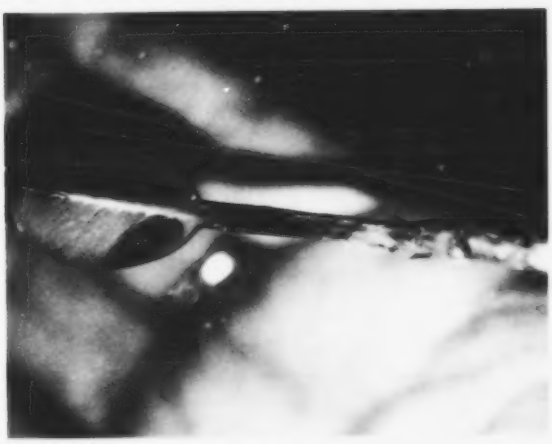

PLATE 12. Distinctive purplish-black lesions of Volutella canker *(Volutella buxi)* on *Buxus* sp.

PLATE 13. Late instar larvae of gypsy moth *(Lymantria dispar),* late May. Note the five pairs of blue dots followed by six pairs of red dots along back.
(Photo: Dave Cheung, University of Guelph)

PLATE 14. Adult female gypsy moth *(Lymantria dispar)* depositing a brown, fuzzy egg mass on tree trunk, early August.
(Photo: Dave Cheung, University of Guelph)

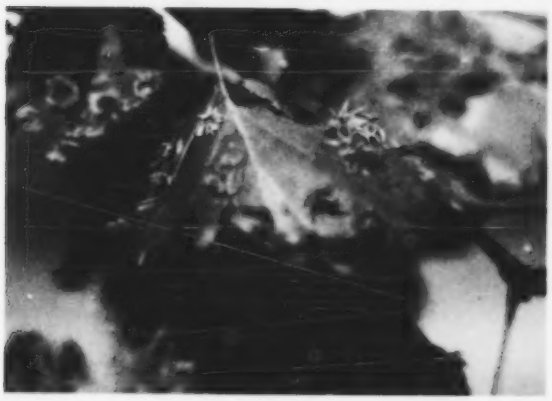

PLATE 15. Hawthorn rust *(Gymnosporangium globosum)* on *Crataegus,* August. Aecia on leaf undersides release aeciospores that infect *Juniperus.*

PLATE 16. Quince rust *(Gymnosporangium clavipes)* on *Crataegus* sp., August. Aecia release aeciospores that can infect *Juniperus.*

PLATE 17. Representative damage by white grubs *(Rhizotrogus majalis* and *Phyllophaga* sp.*)* on *Cornus.*
(Photo: Dave Cheung, University of Guelph)

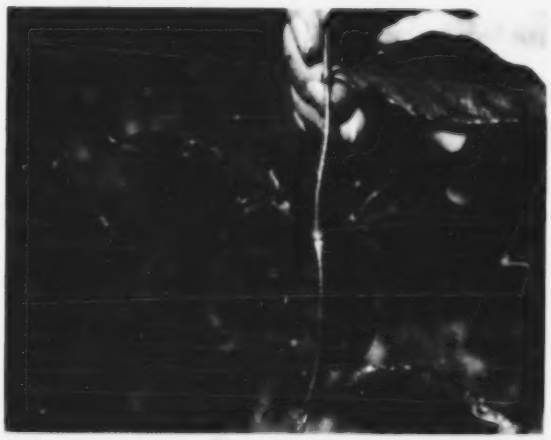

PLATE 18. Septoria leaf spot on *Cornus,* July.

PLATE 7. Verticillium *(V. dahliae, V. albo-atrum)* wilt staining on heartwood (xylem) of *Acer* sp.

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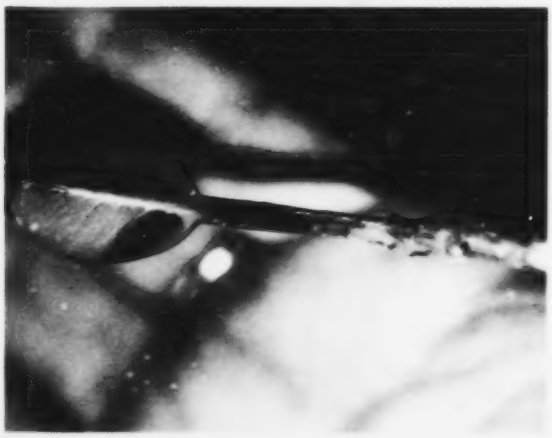

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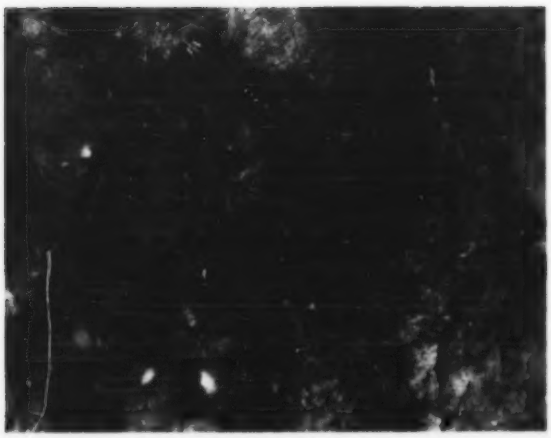

PLATE 13. Late instar larvae of gypsy moth *(Lymantria dispar),* late May. Note the five pairs of blue dots followed by six pairs of red dots along back.
(Photo: Dave Cheung, University of Guelph)

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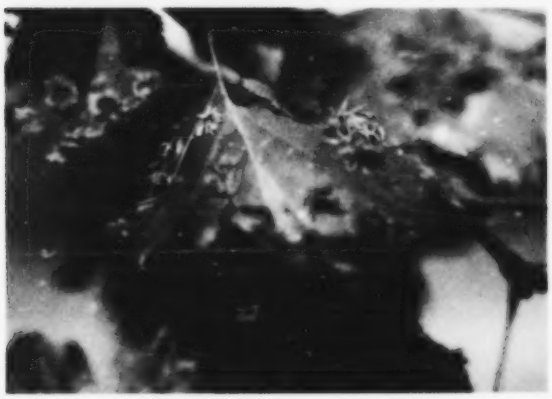
(Photo: Dave Cheung, University of Guelph)



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(Photo: Dave Cheung, University of Guelph)

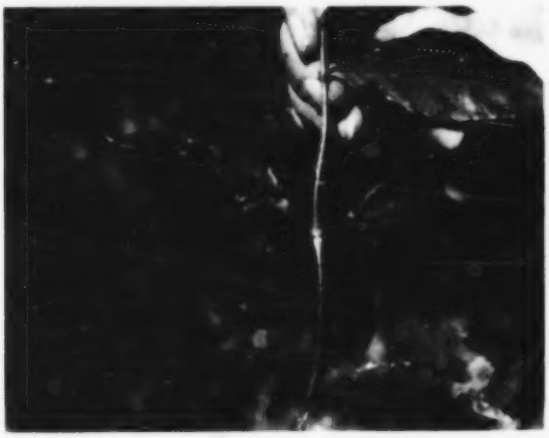


PLATE 18. Septoria leaf spot on *Cornus,* July.

PLATE 19. Brown, dead, persistent leaves as a symptom of *Phytophthora* infection on *Cotoneaster.*

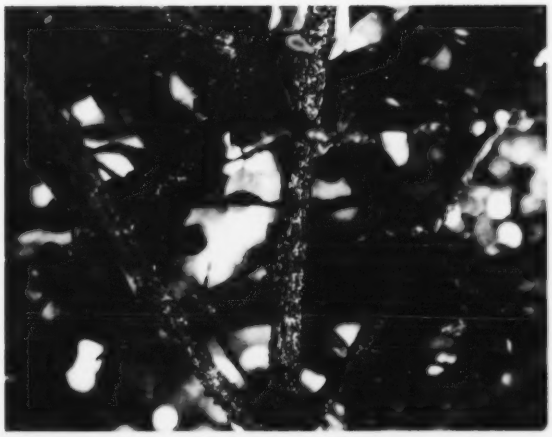


PLATE 20. Euonymus scale *(Unaspis euonymi)* adults appear as white and brown oblong scales on twigs and leaf undersides. (Photo: Dave Cheung, University of Guelph)

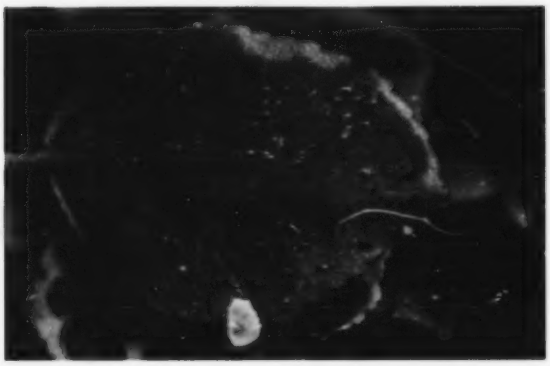


PLATE 21. Tiny, orange crawlers of euonymus scale *(Unaspis euonymi)* on the lower leaf surface. Adult males appear white, while females are brown and oyster-shell shaped. (Photo: Dave Cheung, University of Guelph)

PLATE 22. Euonymus webworm *(Yponomeuta cagnagella)* larvae feeding, June.
(Photo: Dave Cheung, University of Guelph)

PLATE 23. Characteristic circular leaf spots and necrosis caused by Euonymus anthracnose *(Glomerella cingulata* or *Colletotrichum gloeosporioides)* on *Euonymus fortunei.*

PLATE 24. A large crown gall *(Agrobacterium tumefaciens)* on *Euonymus.*

PLATE 25. Serpentine larval gallery caused by emerald ash borer *(Agrilus planipennis)* larva in the cambium of *Fraxinus pennsylvanica*.

PLATE 27. Bore hole and frass/sawdust at base of *Fraxinus pennsylvanica*, caused by leopard moth *(Zeuzera pyrina)*. Bore hole is ascending.

PLATE 29. Honeylocust mite, plant bug and leafhopper damage causing stippling and bronzing of foliage.

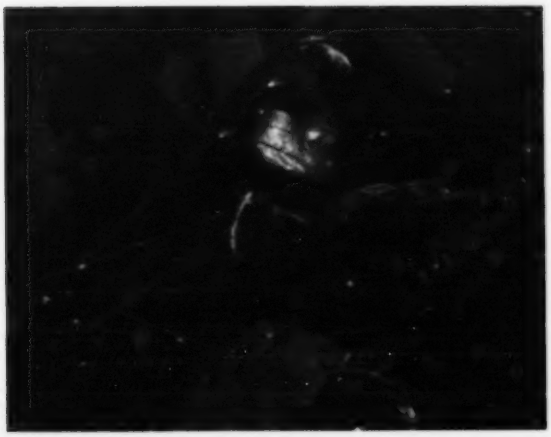


PLATE 26. Fall webworm *(Hyphantria cunea)* larvae feeding at end of branch, August.
(Photo: Dave Cheung, University of Guelph)

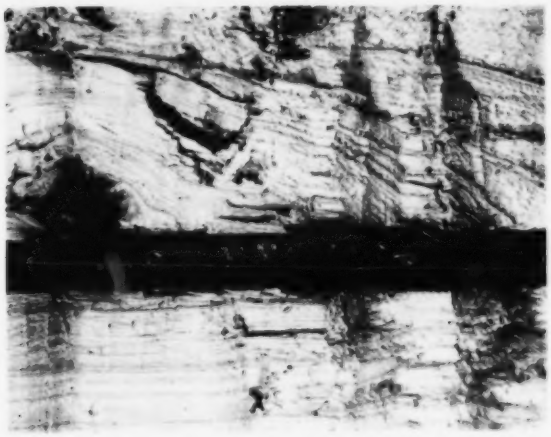


PLATE 28. Leopard moth larva *(Zeuzera pyrina)* in the heartwood of *Fraxinus pennsylvanica*.

PLATE 30. Anthracnose *(Gloeosporium aridum)* on ash causing malformed leaves with necrosis at the edges.

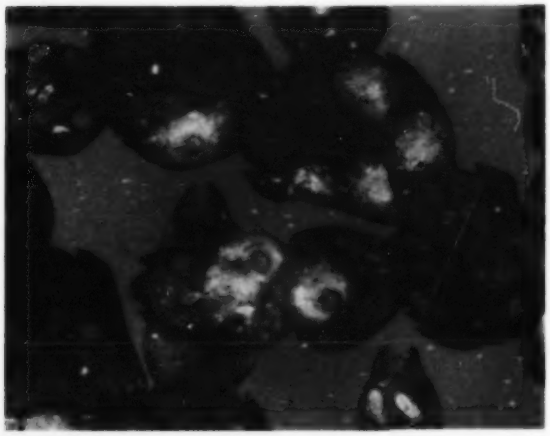


PLATE 31. Adult juniper scale *(Carulaspis juniperi)* with crawlers on foliage, late June.
(Photo: Dave Cheung, University of Guelph)

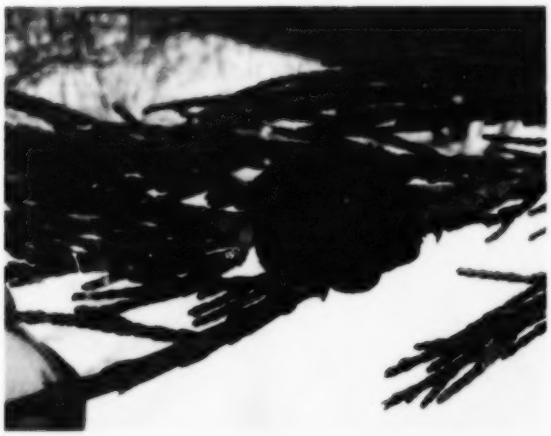


PLATE 32. Cedar-apple rust *(Gymnosporangium juniperi-virginianae)* overwintering gall on juniper foliage, March.

PLATE 33. Cedar-hawthorn rust *(Gymnosporangium globosum)* overwintering gall on juniper foliage. Dormant, March.

PLATE 34. Juniper dieback or tip blight *(Kabatina juniperi)* on juniper showing pinched cankers at base of dead shoot.

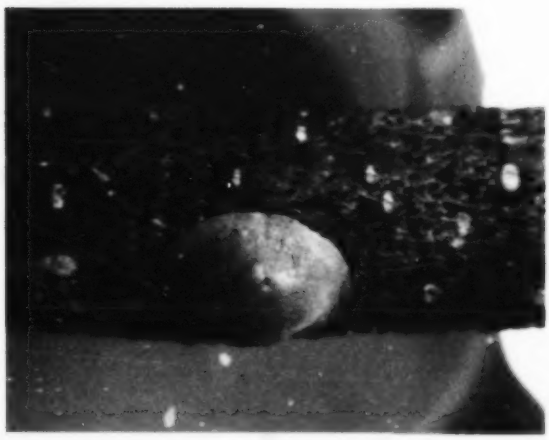


PLATE 35. Overwintering nymphs (tiny black spots) of magnolia scale *(Neolecanium cornuparvum)* and an adult on the twigs of Magnolia, November.

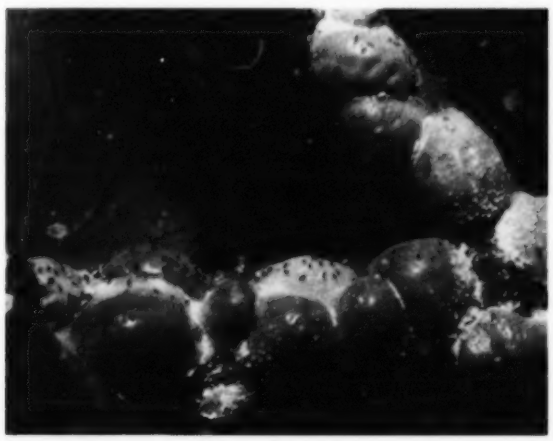


PLATE 36. Mature/dead females of magnolia scale *(Neolecanium cornuparvum)* on the undersides of twigs with white eggs and brown crawlers, early August.

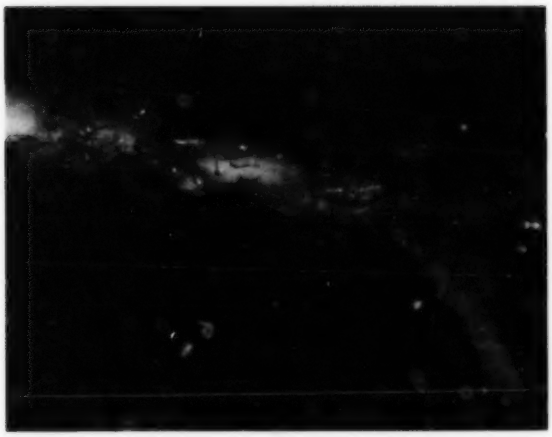


PLATE 37. Greenhouse/potato aphid *(Aulacorthum solani)* colony in greenhouse-grown perennials. (Photo: Dave Cheung, University of Guelph)

PLATE 38. Fall cankerworm *(Alsophila pometaria)* larvae. Note the various colour races.

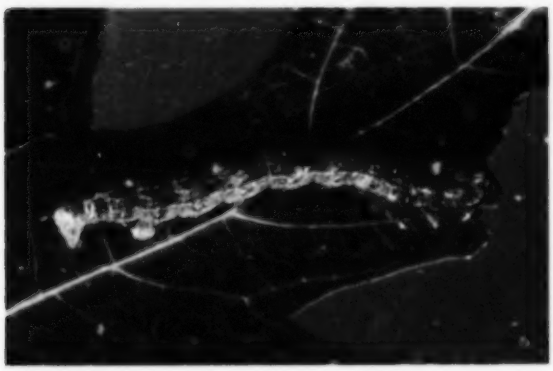


PLATE 39. Spring cankerworm *(Paleacrita vernata)* larva.

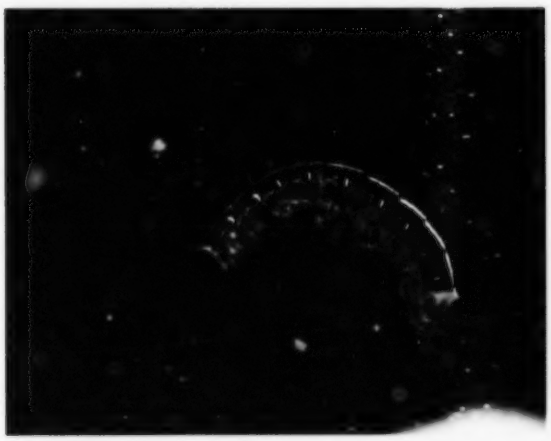


PLATE 40. Eastern tent caterpillar *(Malacosoma americanum)* larva with a solid stripe along its back. (Photo: Dave Cheung, University of Guelph)

PLATE 41. Leafhopper "burn" or stippling damage on *Ptelea* sp.

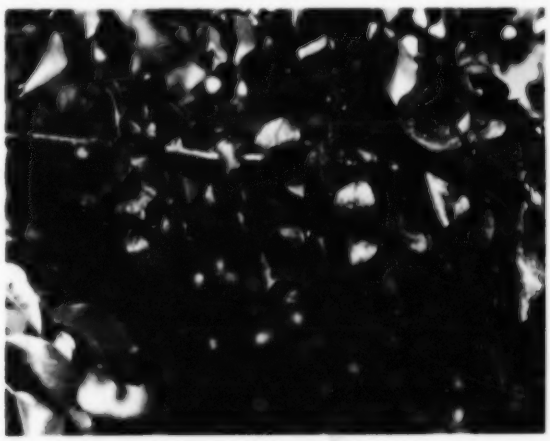


PLATE 42. Fire blight *(Erwinia amylovora)* on *Malus* sp.

PLATE 43. Purplish blotches of apple scab *(Venturia inaequalis)* on *Malus.*

PLATE 44. Cooley spruce gall *(Adelges cooleyi)* formation on *Picea pungens* shoot tip, June.

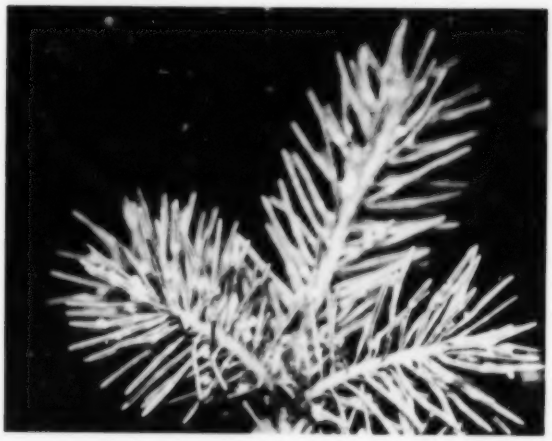


PLATE 45. Cooley spruce gall adelgids *(Adelges cooleyi)* feeding openly on *Pseudotsuga menziesii,* the alternate host, in May.

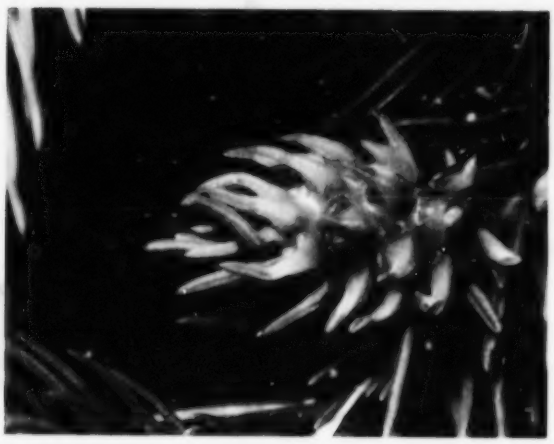


PLATE 46. Eastern spruce gall *(Adelges abietis)* formation on *Picea abies* shoot, June. Galls resemble small pineapples. (Photo: Dave Cheung, University of Guelph)

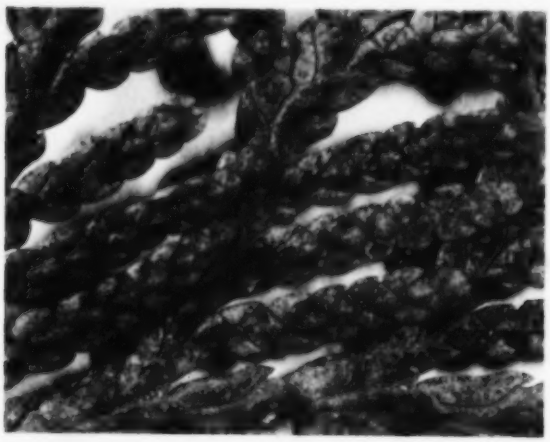


PLATE 47. Spruce spider mite *(Oligonychus ununguis)* feeding damage on *Thuja occidentalis,* September. (Photo: Dave Cheung, University of Guelph)

PLATE 48. Spruce needleminer *(Taniva albolineana* or *Endothenia albolineana)* feeding damage on *Picea.*

PLATE 49. *Cytospora* canker on *Picea*.

PLATE 50. *Rhizosphaera* needlecast on *Picea* showing black fruiting structures in place of stomates. Older needles turn purplish-red and fall off.
(Photo: Tom Hsiang, University of Guelph)

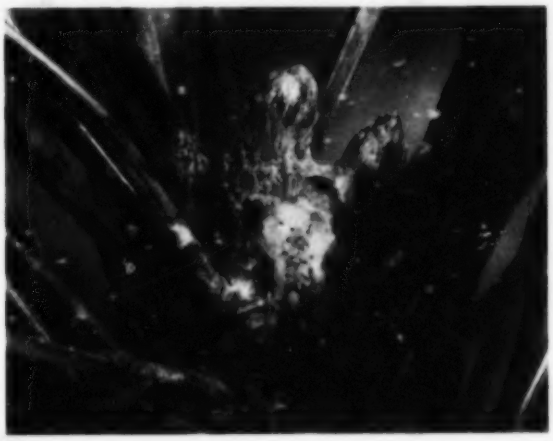


PLATE 51. Feeding damage on emerging shoots caused by European pine shoot moth *(Rhyacionia buoliana)*, May. (Photo: Dave Cheung, University of Guelph)

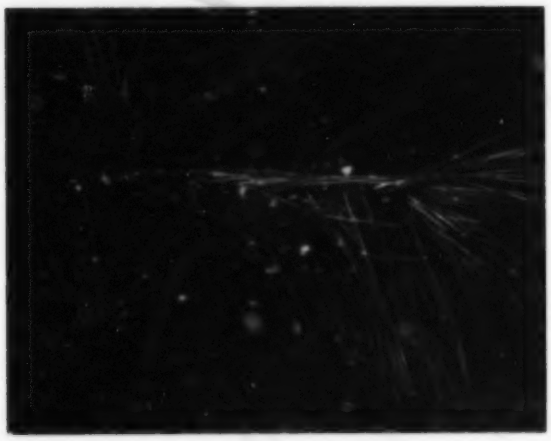


PLATE 52. Feeding damage by adult pales weevil *(Hylobius pales)* on *Pinus strobus*.

PLATE 53. Masses of pine bark adelgid *(Pineus strobi)* on the bark of *Pinus*, May.

PLATE 54. Adult pine needle scale *(Chionaspis pinifoliae)* gives a whitish appearance to foliage of *Pinus*, May.
(Photo: Dave Cheung, University of Guelph)

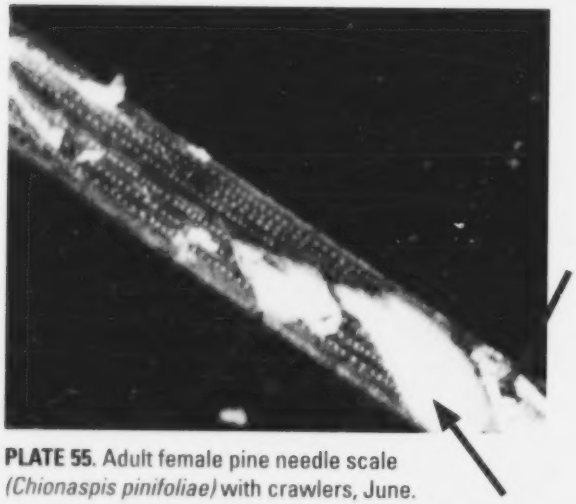


PLATE 55. Adult female pine needle scale *(Chionaspis pinifoliae)* with crawlers, June.

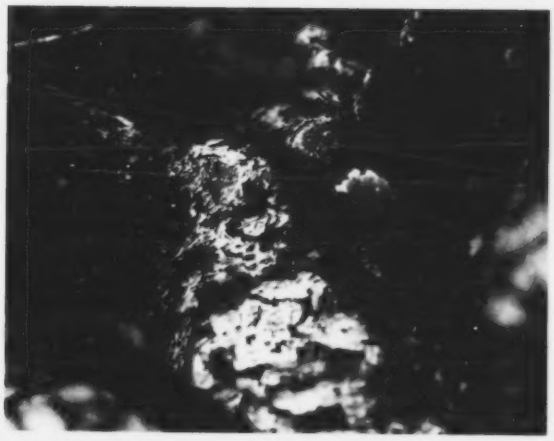


PLATE 56. Pitch masses on bark of *Picea* due to feeding of pine pitch mass borer *(Vespamima pini, Synanthedon pini).*

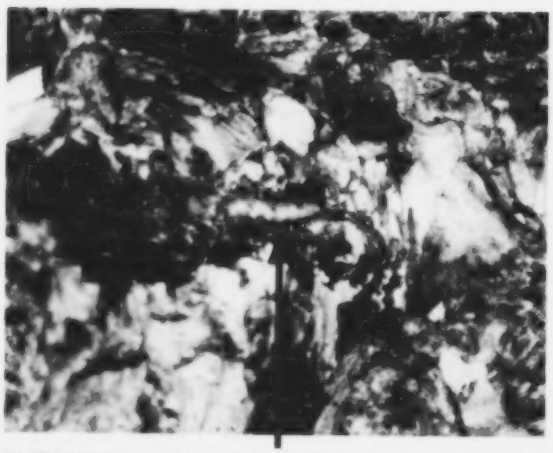


PLATE 57. Pinkish white larva of pine pitch mass borer *(Vespamima pini, Synanthedon pini)* extracted from a pitch mass.

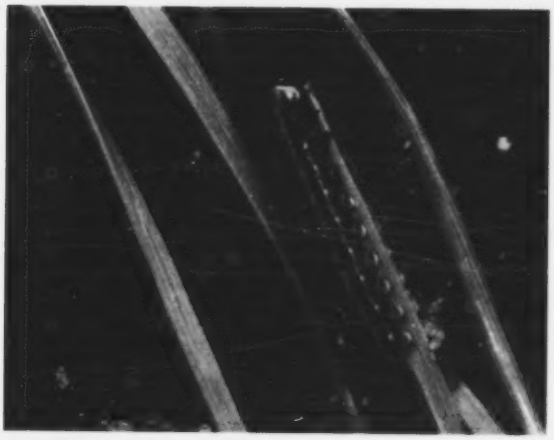


PLATE 58. European pine sawfly larvae *(Neodiprion sertifer).* (Photo: Dave Cheung, University of Guelph)

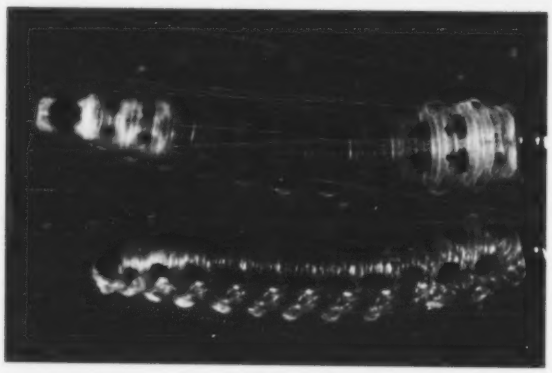


PLATE 59. Redheaded pine sawfly larvae *(Neodiprion lecontei).*

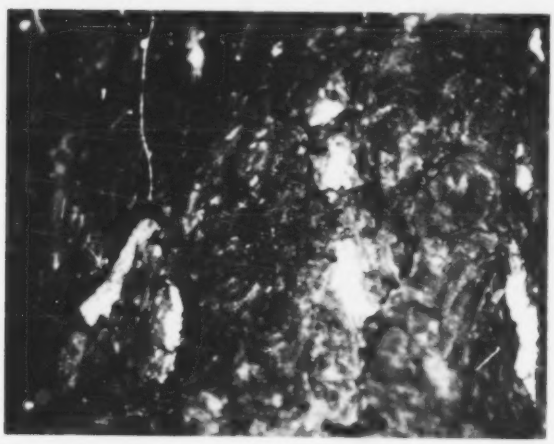


PLATE 60. Egg-laying sites (sap streaks) from the pine shoot beetle *(Tomicus piniperda)* on bark of *Pinus sylvestris,* early spring.

PLATE 61. Larvae and feeding galleries of pine shoot beetle *(Tomicus piniperda)* formed under bark of *Pinus sylvestris*.

PLATE 62. Flagged/broken tip on *Pinus* due to shoot feeding of adult pine shoot beetle *(Tomicus piniperda)*.

PLATE 63. Adult pine shoot beetle *(Tomicus piniperda)* boring out a clean hole in the shoot tip of *Pinus sp.*

PLATE 64. Feeding damage inside terminal caused by white pine weevil *(Pissoides strobi)* larvae.

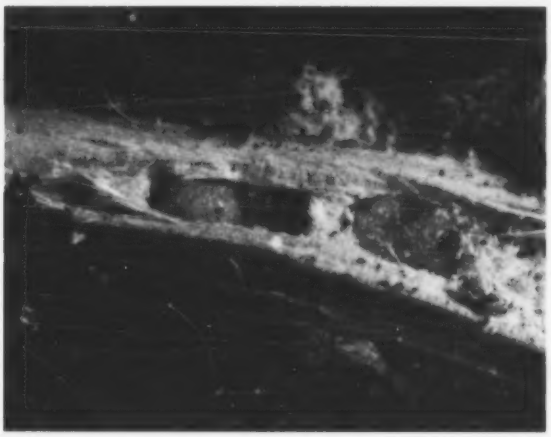


PLATE 65. Legless, white larvae of white pine weevil *(Pissoides strobi)* inside terminal shoot, June. (Photo: Dave Cheung, University of Guelph)

PLATE 66. Stunted, dead new growth on *Pinus nigra* caused by tip blight *(Diplodia pinea* or *Sphaeropsis sapinea)*, June.

PLATE 67. Killed pine needles of previous year's growth due to *Lophodermium* needlecast.

PLATE 68. Canker on main stem of *Pinus strobus,* showing white pine blister rust *(Cronartium ribicola).*

PLATE 69. Cankers, barksplitting, chewed bark and frass caused by peachtree borer larvae *(Synanthedon exitiosa)* inside stem of *Prunus serotina* seedlings. (Photo: Dave Cheung, University of Guelph)

PLATE 70. Damaged limbs of *Prunus* sp. from larvae of lesser peachtree borer *(Synanthedon pictipes).*

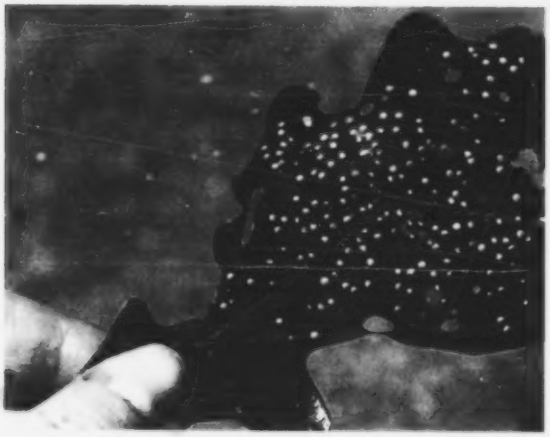


PLATE 71. One of the many types of oak leaf gall.

PLATE 72. Bore hole in *Quercus rubra* caused by an active larva of red oak clearwing moth *(Paranthrene simulans).*

PLATE 73. Physiological leaf scorch on *Quercus rubra,* caused by heat and drought stress.

PLATE 74. Skeletonizing damage on *Vitis* caused by Japanese beetle adults *(Popillia japonica).*

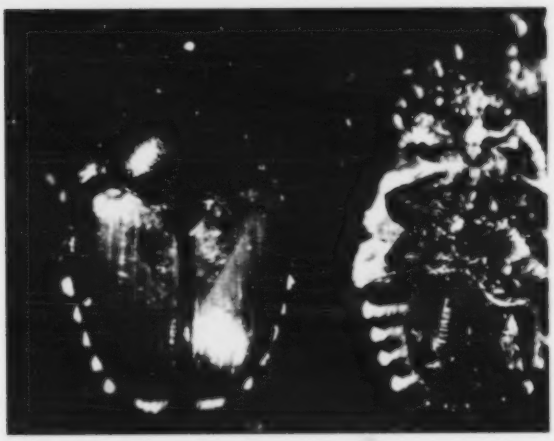


PLATE 75. Adult Japanese beetle *(Popillia japonica),* dorsal and ventral view. Note tufts of white hairs around abdomen.

PLATE 76. Black spot *(Diplocarpon rosae)* lesions on foliage of *Rosa* sp.

PLATE 77. Exit hole from emerged adult lilac borer *(Podosesia syringae),* June.

PLATE 78. Leaf blotches caused by feeding damage of lilac leafminer *(Caloptilia syringella),* June.

PLATE 79. Powdery mildew *(Microsphaera alni)* on *Syringa*, August.

PLATE 80. Notches in margins of *rumex* leaves caused by feeding of adult black vine weevil *(Otiorhynchus sulcatus)*.

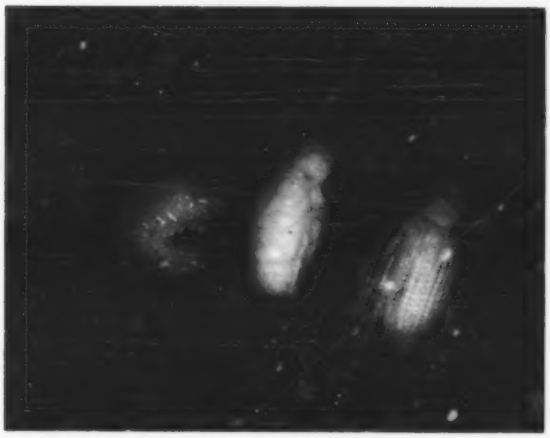


PLATE 81. Legless, white larva, pupa and teneral adult of black vine weevil *(Otiorhynchus sulcatus)*. (Photo: Dave Cheung, University of Guelph)

PLATE 82. Maturing nymphs and adults of Fletcher scale *(Lecanium fletcheri)* on twigs and leaves of *Thuja*. (Photo: Dave Cheung, University of Guelph)

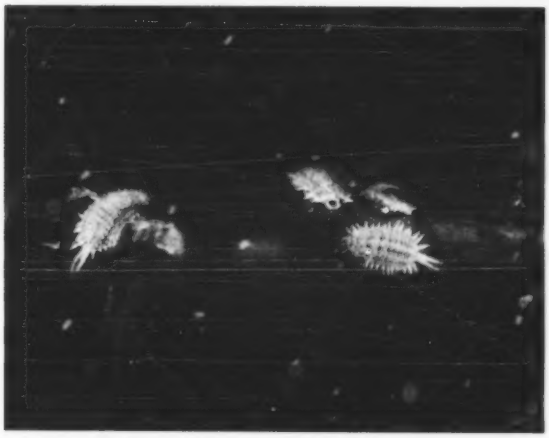


PLATE 83. Adults of taxus mealybug *(Pseudococcus cuspidatae* or *Dysmicoccus wistariae)* on twigs, May. (Photo: Dave Cheung, University of Guelph)

PLATE 84. Foliar tip browning caused by feeding of cedar leaf miner larvae (*Argyresthia thuiella* and other species), June. (Photo: Dave Cheung, University of Guelph)

PLATE 85. Foliar bronzing and some twig bark girdling on *Thuja occidentalis*, caused by strawberry root weevil *(Otiornynchus ovatus)* adults.
(Photo: Dave Cheung, University of Guelph)

PLATE 86. Tarnished plant bug *(Lygus lineolaris)* nymph.
(Photo: Dave Cheung, University of Guelph)

PLATE 87. Adult strawberry root weevils *(Otiorhynchus ovatus)* appear as small (4–6 mm) brownish-black weevils.

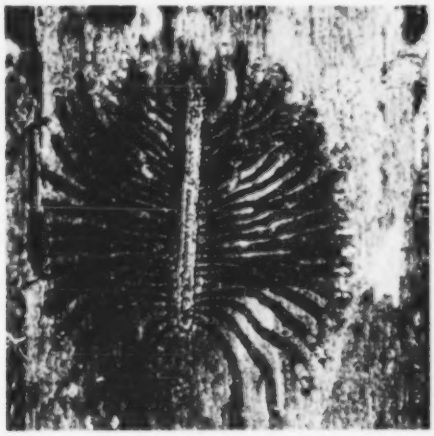


PLATE 88. Representative larval gallery of elm bark beetle *(Scolytus multistriatus, Hylurgopinus rufipes)* in cambium.

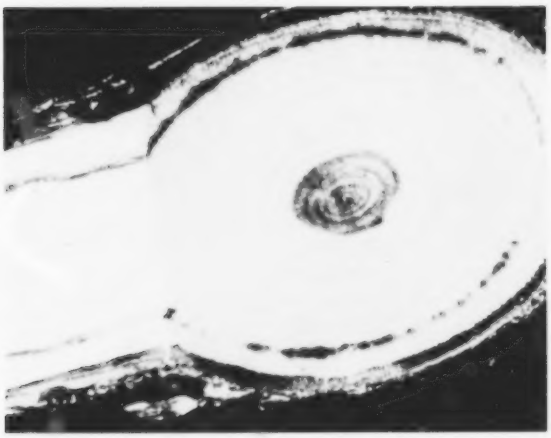


PLATE 89. Infection of xylem by Dutch elm disease *(Ceratocystis ulmi)* causes stained rings in wood.

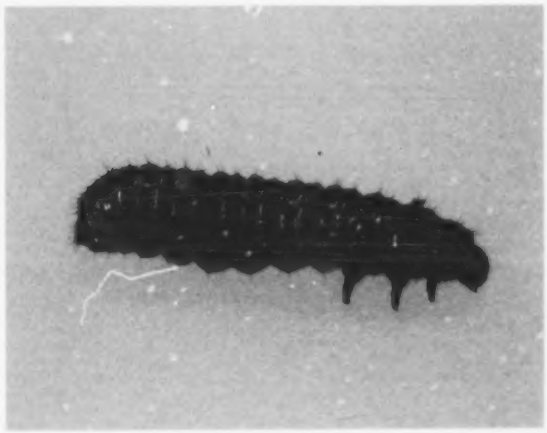


PLATE 90. Viburnum leaf beetle *(Pyrrhalta viburni)* larva, May. (Photo: Dave Cheung, University of Guelph)

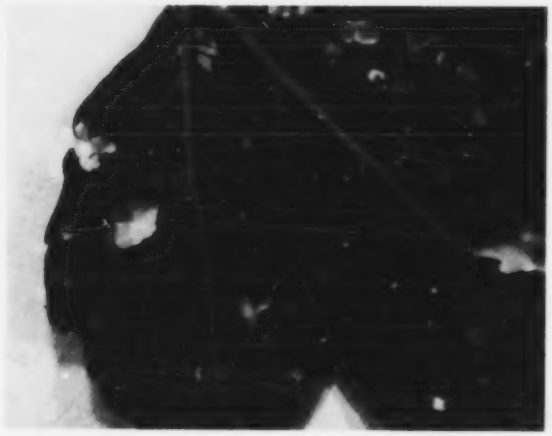


PLATE 91. Skeletonizing damage due to feeding of viburnum leaf beetle *(Pyrrhalta viburni)* larvae, June. Note the different colour races. (Photo: Dave Cheung, University of Guelph)

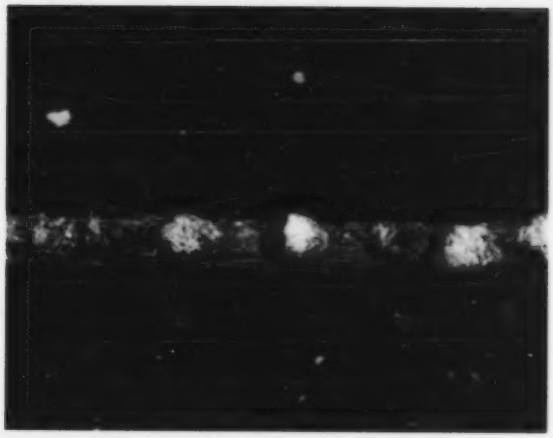


PLATE 92. Overwintering egg-laying sites (on twig undersides) of viburnum leaf beetle *(Pyrrhalta viburni)*, August. (Photo: Dave Cheung, University of Guelph)

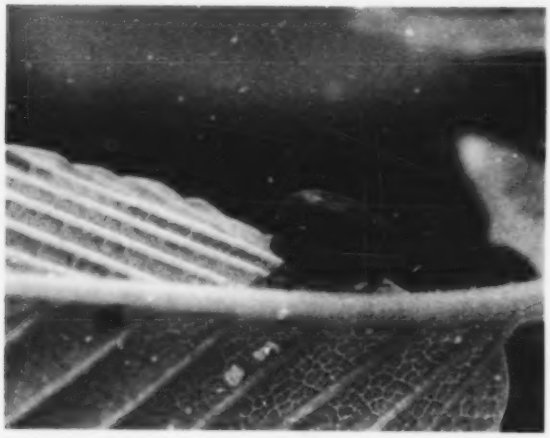


PLATE 93. Adult elm flea weevils *(Orchetes alni)* mating and laying eggs on foliage of *Ulmus pumila*. (Photo: Dave Cheung, University of Guelph)

PLATE 94. Larvae of pine false webworm *(Acantholyda erythrocephala)* showing web with frass behind larva. (Photo: Dave Cheung, University of Guelph)

The photos on these pages were provided by the University of Guelph, Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs.

Emergency and First-Aid Procedures for Pesticide Poisoning

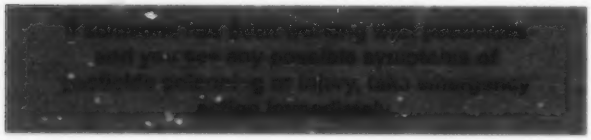
For a major spill, a theft or a fire involving a pesticide call the Ministry of the Environment at **1-800-268-6060.**

For pesticide poisonings and pesticide injuries call the Poison Information Centre:

Toronto 1-800-268-9017
1-877-750-2233 (TTY)

PREVENT ACCIDENTS

- **Read the label.** Follow all the precautions the label recommends. Read the First Aid section of the label BEFORE you begin to handle any pesticide.
- **Make sure that someone knows** what pesticides you are working with and where you are.
- **Keep a file of labels and product Material Safety Data Sheets (MSDS) for the pesticides you use.** Make sure everyone knows where to find this in case of an emergency.
- **Post emergency numbers near all telephones.**
- **Keep clean water, paper towels, extra gloves and clean coveralls close by** in case you spill pesticide on yourself.



IF AN ACCIDENT OR POISONING HAPPENS

- Protect yourself from injury first.
- Stop the exposure to the pesticide. Move the victim away from the contaminated area.
- Check the four basic facts — identify the pesticide, the quantity, the route of entry and time of exposure.
- Call an ambulance or the Poison Information Centre.
- Start first aid. This is not a substitute for professional medical help.
- **Provide the label, MSDS sheet or container to emergency personnel** at the scene — or take it with you to the hospital. Do not transport pesticide containers in the passenger compartment of the vehicle.

FIRST AID

If a pesticide comes in contact with skin:

- remove all contaminated clothing; wash skin thoroughly with lots of soap and warm water
- dry skin well and cover with clean clothing or other clean material.

If pesticide comes in contact with eyes:

- hold eyelids open; wash the eyes with clean running water for 15 minutes or more.

If pesticide was inhaled:

- move the victim to fresh air and loosen tight clothing
- give artificial respiration if the victim is not breathing.

Do not breathe in the exhaled air from the victim — you could also be poisoned.

If a pesticide was swallowed:

- **call the Poison Information Centre IMMEDIATELY.**

Emergency numbers are listed at the front of each Bell telephone directory.

To obtain copies of this or any other OMAFRA publication, please order:

- online at www.serviceontario.ca/publications
- by phone through the ServiceOntario Contact Centre, Monday to Friday, 8:30 AM to 5:00 PM ET
  - 416-326-5300
  - 416-326-3408 (TTY)
  - 1-800-668-9938, toll-free across Canada
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- **Post emergency numbers near all telephones.**
- **Keep clean water, paper towels, extra gloves and clean coveralls close by** in case you spill pesticide on yourself.

If someone has been working with pesticides and you see any possible symptoms of pesticide poisoning or injury, take emergency action immediately.

IF AN ACCIDENT OR POISONING HAPPENS

- Protect yourself from injury first.
- Stop the exposure to the pesticide. Move the victim away from the contaminated area.
- Check the four basic facts — identify the pesticide, the quantity, the route of entry and time of exposure.
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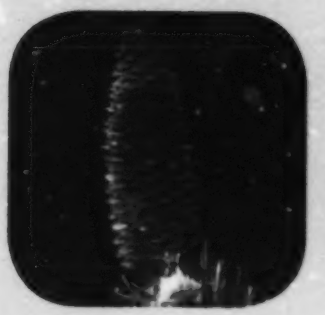

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